US Army Corps
of Engineers
Buffalo District

Blanchard River Flood Risk Management Feasibility Study Appendix B – Economics (DRAFT)

April 2015

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1.0 Introduction

Historically, significant flooding impacts in the Blanchard River Watershed have occurred in the city of Findlay. Opportunities to reduce the annual flood risk and resulting property damages incurred by residents, business owners, and the government, include structural and nonstructural measures. The Blanchard River Watershed Study was initiated to identify and evaluate flood risk management alternatives for the metropolitan area of Findlay, OH as requested by Hancock County, the non-Federal partner.

This economic appendix provides clarity on the methods employed throughout the economic analysis, focusing on flood risk management alternatives for the city of Findlay. Additional information can be found in the main report and other appendices.

1.1 Study Area

The study area is the Blanchard River Watershed, focused on the city of Findlay. Findlay is located in Hancock County (Figure 1-1) approximately 50 miles south of Toledo and roughly 50 river miles upstream of the confluence of the Blanchard and Auglaize Rivers.

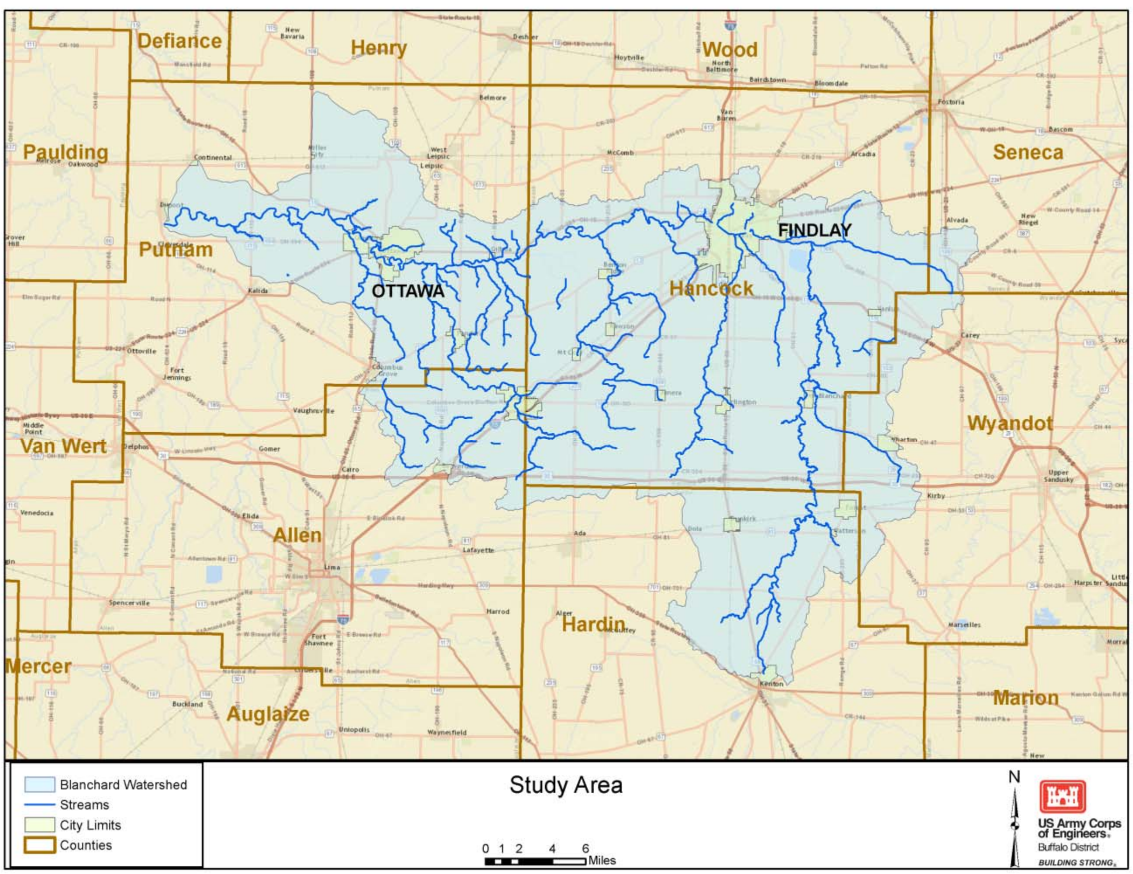


Figure 1-1: Study Area

1.2 Flood History

River flooding, flash flooding, and urban flooding are the predominant types of flooding that occur in the Blanchard River Basin. Although the primary sources of flooding in this basin are the Blanchard River and its tributaries, flooding may also occur in urbanized areas as a result of increased imperviousness and inadequate drainage. Flooding is more common during the spring as a result of heavy rains, combined with melting snow. This region has experienced many flood disasters that resulted in Presidential and Gubernatorial Disaster Declarations. These disasters have caused millions of dollars in damages to homes, businesses, personal property, and agriculture. The most significant flooding impacts in the watershed have occurred in the city of Findlay and the village of Ottawa, where the primary problem is frequent and serious flooding that inundates high-value downtown business district. These frequent floods (most recently in 2006, 2007, 2008, 2011, and 2013) caused extensive damage to downtown businesses and nearby residential areas. During flood events, water levels often remain above flood stage for several days. Extensive rescue operations are required during the floods and major cleanup and restoration expenses are incurred by local, state, and federal governments.

The Blanchard River, Eagle Creek, and Lye Creek all converge in Findlay's downtown business district. According to the U.S. Geological Survey, stream gage data at Findlay, the Blanchard River has reached flood stage at least once in 15 of the last 20 years. The National Weather Service reports that Findlay experienced five flooding events between December 2006 and March 2009 that were considered greater than the 10-percent-chance (10-year) flood event; and two of the five floods were within the top five floods ever recorded in Findlay.

Small-scale flood risk management efforts are being undertaken by local communities in the study area, including projects to elevate or acquire at-risk structures, a flood warning system, and clearing and snagging of the Blanchard River and its tributaries.

1.3 Existing Conditions

The primary development within the study area is residential, with approximately 5,000 residences in Findlay estimated to receive damages in the 1-percent-chance (100-year) flood event. These numbers represent mostly single and multi-family residences, but also include a small number of mobile homes. The nonresidential structures in the study area are primarily small businesses.

The Blanchard River Watershed is located in the center of an extensive transportation network of road and rail systems. The level of accessibility afforded by this network has contributed significantly to both local and regional economic growth. Although Hancock County is largely rural, it is also home to many businesses, (including Cooper Tire, Hearthside Foods, Marathon Petroleum, and Whirlpool Corporation) that are able to quickly and easily export manufactured goods using the area's many convenient State routes and interstates.

During flood events, transportation infrastructure in the study area (including, but not limited to, I-75) is significantly impacted. Closure times range from short to relatively long to account for inundation, debris clearance, and safety assessments which vary by storm and particular transportation route. During major flood events, a majority of the Blanchard River crossings are closed. Major flooding has also resulted in the closure of several Blanchard River rail crossings.

1.4 Population Size and Composition

Five-year average (2008-2012) American Community Survey (ACS) data was queried to obtain relevant socioeconomic data for this analysis. The ACS data is tabulated by the U.S. Census Bureau and was procured at the national, state, county and local levels (USCB, 2014a).

According to the ACS Demographics and Housing Estimates from 2008-2012, the Findlay, Ohio area has a total population of 41,301. Of this total population male and female percentages are 46.8% and 53.2%, respectively. The median age within Findlay is 36.2 years. Nationally, the male and female populations are almost a 1:1 ratio of 49.2% and 50.80%. The median age in the United States is estimated to be 37.2 years. Persons under age 18 comprise 21.9% of the total population of Findlay, compared to 23.9% nationally. The percentage of residents over the age of 65 (14.5%) is higher than the national percentage (13.2%). Figure 1-2 below depicts the population densities in Findlay, OH.

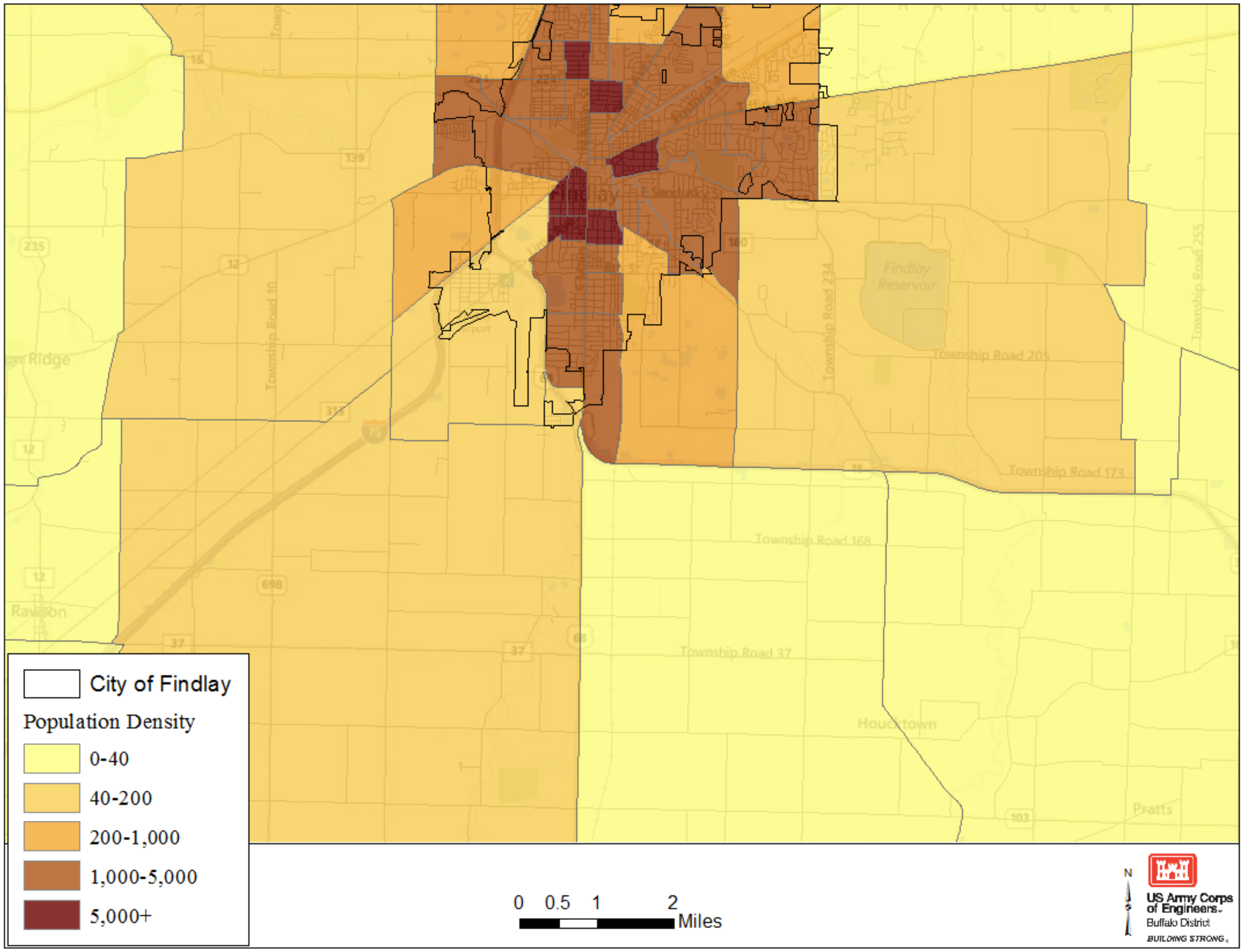


Figure 1-2: Population Densities within the City of Findlay (Source, ACS, 2008-2012)

Estimates for population from the U.S. Census Bureau's QuickFacts from 2010-2013 show the city of Findlay, as well as both Hancock County and the State of Ohio, are increasing in population. Hancock County had an increase of 1.3% of the population while the State of Ohio had a 0.3% increase. The city of Findlay fell between the county and state with a 0.8% increase. The City of Findlay represents 55% of Hancock County's total population. Table 1-1 represents a summary of demographic data from the United States, Ohio, Hancock County, and the city of Findlay.

Table 1-1: ACS Demographic and Housing Estimates (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Total Population	309,138,711	100%	11,533,561	100%	75,043	100%	41,301	100%
Male	152,018,799	49.20%	5,630,373	48.8%	36,241	48.03%	19,341	46.80%
Female	157,119,912	50.80%	5,903,188	51.20%	38,802	51.70%	21,960	53.20%
Under 5 years of age	20,137,884	6.50%	712,820	6.20%	4,615	6.10%	2,698	6.50%
5 to 9 years	20,311,310	6.60%	750,218	6.50%	4,799	6.40%	2,334	5.70%
10 to 14 years	20,647,280	6.70%	770,410	6.70%	4,903	6.50%	2,266	5.50%
15 to 19 years	21,930,781	7.10%	817,811	7.10%	5,507	7.30%	3,261	7.90%
20 to 24 years	21,775,439	7.00%	766,409	6.60%	5,466	7.30%	3,771	9.10%
25 to 34 years	41,184,290	13.30%	1,402,955	12.30%	9,305	12.40%	5,772	14.00%
35 to 44 years	41,227,505	13.30%	1,482,197	12.90%	9,337	12.40%	4,906	11.90%
45 to 54 years	44,646,979	14.40%	1,724,093	14.90%	10,895	14.50%	5,514	13.40%
55 to 59 years	19,680,816	6.40%	784,545	6.80%	4,891	6.50%	2,435	5.90%
60 to 64 years	16,924,986	5.50%	669,501	5.80%	4,348	5.80%	2,366	5.70%
65 to 74 years	22,012,061	7.10%	860,348	7.50%	5,762	7.70%	2,883	7.00%
75 to 84 years	13,147,248	4.30%	543,287	4.70%	3,403	4.50%	1,913	4.60%
85 years and over	5,512,132	1.80%	230,967	2.00%	1,812	2.40%	1,182	2.90%
Median age (years)	37.2	N/A	38.8	N/A	38.4	N/A	36.2	N/A

1.5 Housing Characteristics

The ACS five year estimates from 2008-2012 indicate that there are 19,198 households within Findlay. Of this number approximately, 9.5% are vacant. This vacancy rate is slightly higher than the county average, but lower than the state and national averages. Of the 17,373 occupied units, 67.5% are single-unit (attached or detached), 25.9% are multi-unit structures, and 6.5% are mobile homes. These households are 60.1% owner-occupied and 39.9% renter-occupied. The average household sizes of these owner-occupied and renter-occupied households are 2.39 and 2.12 people, respectively.

The median home value within Findlay is $122,900, which is lower than the county ($129,800), state ($133,700), and national median value ($181,400). Based on the 2008-2012 ACS five year estimates, the median monthly housing cost for mortgaged owners was $1,161, which is lower than the county ($1,303), state ($1,204), and national averages ($1,559). Of the households with a mortgage, 25% spend more than 30% of their household income on their mortgage (36.8% nationally). Table 1-2 summarizes the key housing statistics for the United States, the State of Ohio, Hancock County, and the city of Findlay.

Table 1-2: Selected Housing Characteristics, Findlay, Ohio (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Housing Occupancy								
Total housing units	131,642,457	100%	5,124,503	100%	33,171	100%	19,198	100%
Occupied housing units	115,226,802	87.50%	4,555,709	88.90%	30,342	91.50%	17,373	90.50%
Vacant housing unit	16,415,655	12.50%	568,794	11.10%	2,829	8.50%	1,825	9.50%
Homeowner vacancy rate	2.3	N/A	2.3	N/A	1.6	N/A	1.6	N/A
Rental vacancy rate	7.5	N/A	8.5	N/A	9.2	N/A	9.8	N/A
Value								
Owner-occupied units	75,484,661	100%	3,098,283	100%	21,332	100%	10,444	100%
Less than $50,000	6,507,037	8.60%	266,370	8.60%	1,691	7.90%	735	7.00%
$50-00 to $99,999	11,459,242	15.20%	737,128	23.80%	4,893	22.90%	2,563	24.50%
$100,000 to $149,999	11,902,702	15.80%	778,499	25.10%	6,068	28.40%	3,561	34.10%
$150,000 to $199,999	11,341,489	15.00%	568,230	18.30%	4,148	19.40%	1,878	18.00%
$200,000 to $299,999	13,962,144	18.50%	463,559	15.00%	2,966	13.90%	1,036	9.90%
$300,000 to $499,999	12,119,827	16.10%	208,889	6.70%	1,192	5.60%	486	4.70%
$500,000 to $999,999	6,546,005	8.70%	59,268	1.90%	313	1.50%	154	1.50%
$1,000,000 or more	1,646,215	2.20%	16,340	0.50%	61	0.30%	31	0.30%
Median (dollars)	181,400	N/A	133,700	N/A	129,800	N/A	122,900	N/A
Mortgage Status								
Owner-occupied units	75,484,661	100.00%	3,098,283	100.00%	21,332	100.00%	10,444	100%
Housing units with a mortgage	50,671,257	67.10%	2,099,448	67.80%	14,294	67.00%	7,023	67.20%
Housing units without a mortgage	24,813,404	32.90%	998,835	32.20%	7,038	33.00%	3,421	32.80%
Selected Monthly Owners Cost								
Housing units with a mortgage	50,671,257	100.00%	2,099,448	100.00%	14,294	100.00%	7,023	7,023
Less than $300	90,178	0.20%	4,706	0.20%	63	0.40%	45	0.60%
$300 to $499	803,497	1.60%	44,503	2.10%	366	2.60%	160	2.30%
$500 to $699	2,479,280	4.90%	132,452	6.30%	898	6.30%	478	6.80%
$700 to $999	6,945,037	13.70%	397,076	18.90%	3,507	24.50%	1,878	26.70%
$1,000 to $1,499	13,664,107	27.00%	740,391	35.30%	5,237	36.60%	2,489	35.40%
$1,500 to $1,999	10,299,293	20.30%	425,335	20.30%	2,483	17.40%	1,228	17.50%
$2,000 or more	16,389,865	32.30%	354,985	16.90%	1,740	12.20%	745	10.60%
Median (dollars)	1,559	N/A	1,303	N/A	1,204	N/A	1,161	N/A
Housing units without a mortgage	24,813,404	100.00%	998,835	100.00%	7,038	100.00%	3,421	N/A
Less than $100	293,726	1.20%	5,666	0.60%	41	0.60%	29	0.80%
$100 to $199	1,688,436	6.80%	47,632	4.80%	379	5.40%	189	5.50%
$200 to $299	3,798,299	15.30%	143,754	14.40%	1,348	19.20%	687	20.10%
$300 to $399	4,631,964	18.70%	223,923	22.40%	1,771	25.20%	887	25.90%
$400 or more	14,400,979	58.00%	577,860	57.90%	3,499	49.70%	1,629	47.60%
Median (dollars)	449	N/A	438	N/A	399	N/A	389	N/A

1.6 Race and Ethnic Diversity

While ethnic diversity in Findlay is much lower than the state and national levels, there seems to be an upward trend in the ratio of non-white residents to white residents. Findlay indicates an increase in the percentage of minority persons (as a whole) for the total population of 41,301 people. The largest three races by proportion are White (91.3%), Black or African American (2.7%), and Asian (2.6%). Table 1-3 below summarizes population by race at the four geographical study areas for comparison.

Table 1-3: Population Ethnicity (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Race								
Total population	309,138,711	100%	11,533,561	100%	75,043	100%	41,301	100%
One race	300,842,420	97.3%	11,291,272	97.9%	74,119	98.8%	40,562	98.2%
White	229,298,906	74.2%	9,577,732	83.0%	70,460	93.9%	37,718	91.3%
Black or African American	38,825,848	12.6%	1,403,238	12.2%	1,197	1.6%	1,116	2.7%
American Indian and Alaska Native	2,529,100	0.8%	21,447	0.2%	157	0.2%	0	0.0%
Asian	14,859,795	4.8%	196,395	1.7%	1,272	1.7%	1,071	2.6%
Native Hawaiian and Other Pacific Islander	514,402	0.2%	2,164	0.0%	48	0.1%	38	0.1%
Some other race	14,814,369	4.8%	90,296	0.8%	985	1.3%	619	1.5%
Two or more races	8,296,291	2.7%	242,289	2.1%	924	1.2%	739	1.8%
Race alone or in combination with one or more other races								
Total population	309,138,711	100%	11,533,561	100%	75,043	100%	41,301	100%
White	236,362,158	76.5%	9,797,950	85.0%	71,365	95.1%	38,440	93.1%
Black or African American	41,945,466	13.6%	1,544,906	13.4%	1,617	2.2%	1,397	3.4%
American Indian and Alaska Native	5,049,092	1.6%	91,674	0.8%	401	0.5%	202	0.5%
Asian	17,285,143	5.6%	238,889	2.1%	1,498	2.0%	1,277	3.1%
Native Hawaiian and Other Pacific Islander	1,107,434	0.4%	8,137	0.1%	48	0.1%	38	0.1%
Some other race	16,417,278	5.3%	113,731	1.0%	1,115	1.5%	725	1.8%
Hispanic or Latino and Race								
Total population	309,138,711	100%	11,533,561	100%	75,043	100%	41,301	100%
Hispanic or Latino (of any race)	50,545,275	16.4%	354,910	3.1%	3,409	4.5%	2,296	5.6%
Not Hispanic or Latino	258,593,436	83.6%	11,178,651	96.9%	71,634	95.5%	39,005	94.4%
White alone	196,903,968	63.7%	9,353,385	81.1%	68,155	90.8%	36,133	87.5%
Black or African American alone	37,786,591	12.2%	1,385,192	12.0%	1,195	1.6%	1,114	2.7%
American Indian and Alaska Native alone	2,050,766	0.7%	17,276	0.1%	157	0.2%	0	0.0%
Asian alone	14,692,794	4.8%	194,696	1.7%	1,272	1.7%	1,071	2.6%
Native Hawaiian and Other Pacific Islander alone	480,063	0.2%	1,909	0.0%	48	0.1%	38	0.1%
Some other race alone	616,191	0.2%	13,818	0.1%	48	0.1%	48	0.1%
Two or more races	6,063,063	2.0%	212,375	1.8%	759	1.0%	601	1.5%

1.7 Education

Of those residents within the city of Findlay over 25 years of age, 89.8% have a high school degree or greater and 23.3% of the population have a bachelor's degree or greater. This is compared, respectively, to 85.7% and 28.5% nationally. Figure 1-3 depicts education levels per block group by percentage of the population with less than a 12th grade education. Figure 1-4 displays education levels per block group by percentage of the population with a high school diploma. Figure depicts education levels per block group by percentage of the population with a college degree.

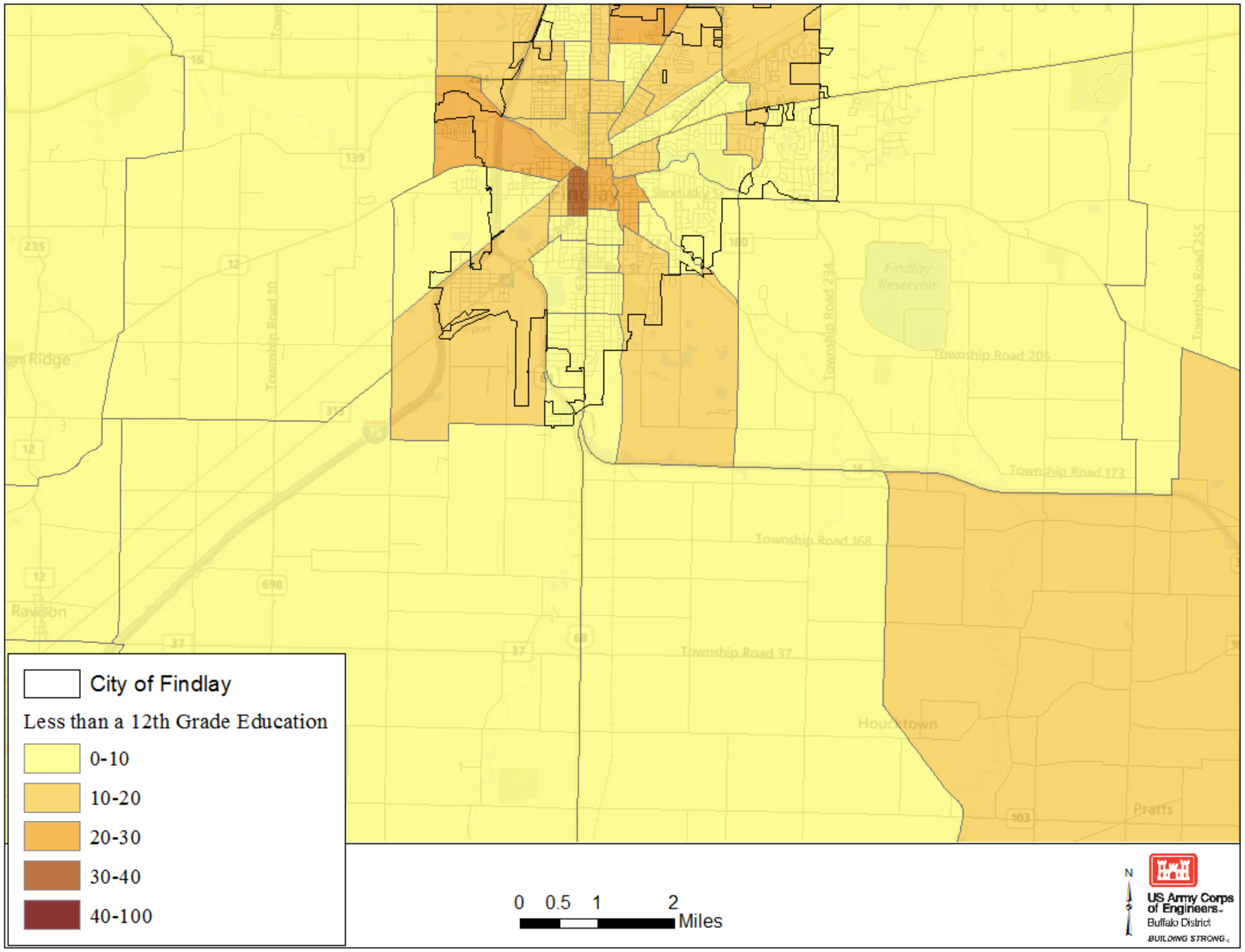


Figure 1-3: Block group distribution of populations with less than a 12th grade education (Source, ACS, 20082012)

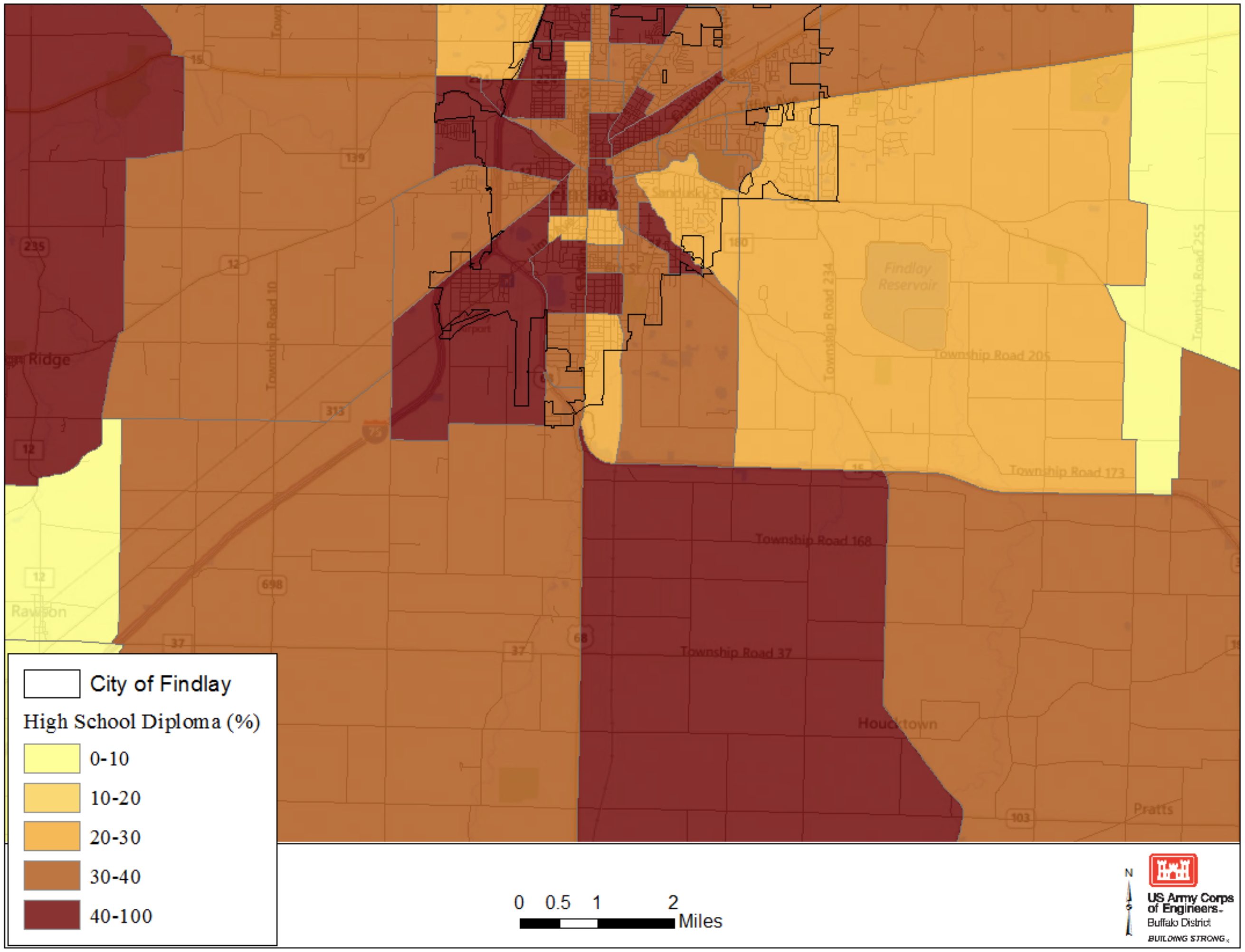


Figure 1-4: Block group distribution of populations with a high school diploma (Source, ACS, 2008-2012)

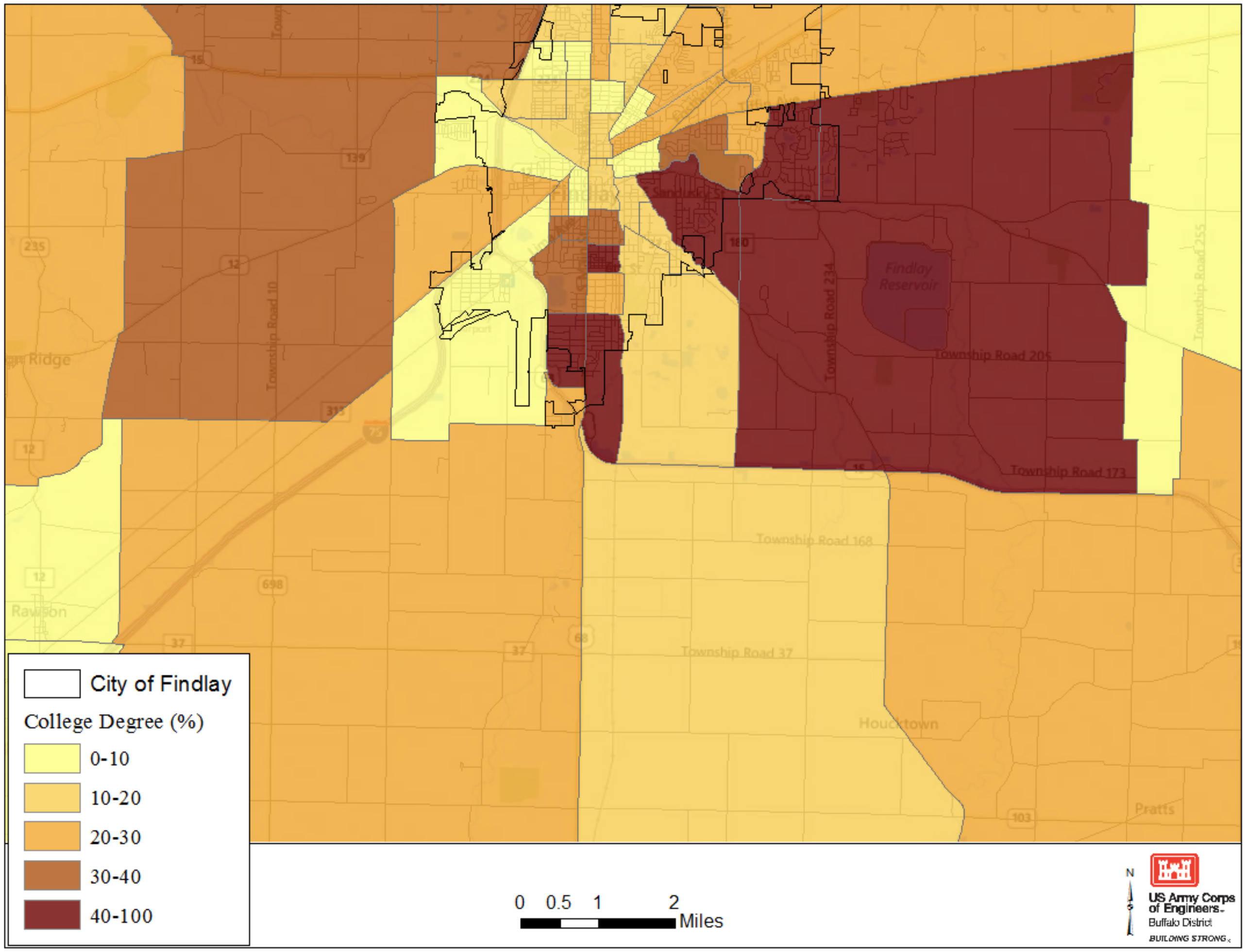


Figure 1-5: Block group distribution of populations with a college degree (Source, ACS, 2008-2012)

1.8 Income

Median earnings within Findlay are lower for residents who have a high school diploma and those who have a bachelor's degree compared to the national average. Nationally, those with a high school diploma earn $33,048 annually while those with a bachelor's degree earn $50,096 compared to $28,848 and $40,667 in the city of Findlay, respectively.

Table 1-4 represents the breakdown of ages to education levels at four geographic scales: the City of Findlay, Hancock County, Ohio, and the United States. Table 1-5 depicts the breakdown of median earnings by education level at the same four geographic scales.

The median household income for the city of Findlay ($43,101) is lower than county ($49,350), state ($48,246), and federal ($53,046) median incomes. In addition, the median family income is also lower than the other three geographical study areas, and per capita income is 4% lower than both Hancock County and the State of Ohio and 11% lower than the per capita income of the United States.

Table 1-6 shows the breakdown of household and family incomes for all four geographical areas.

Table 1-4: Educational Attainment (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Total	Percent
Population 18 to 24 years	30,822,835	100%	1,099,590	100%	7,731	100%	5,295	100%
Less than high school graduate	4,993,299	16.2%	171,536	15.6%	920	11.9%	667	12.6%
High school graduate (includes equivalency)	9,123,559	29.6%	339,773	30.9%	2,543	32.9%	1,589	30.0%
Some college or associate's degree	13,839,453	44.9%	491,517	44.7%	3,657	47.3%	2,573	48.6%
Bachelor's degree or higher	2,866,524	9.3%	96,764	8.8%	611	7.9%	466	8.8%
Population 25 years and over	204,336,017	100%	7,715,893	100%	49,753	100%	26,971	100%
Less than 9th grade	12,260,161	6.0%	254,624	3.3%	945	1.9%	674	2.5%
9th to 12th grade, no diploma	16,755,553	8.2%	655,851	8.5%	3,532	7.1%	2,077	7.7%
High school graduate (includes equivalency)	57,622,757	28.2%	2,692,847	34.9%	18,608	37.4%	9,143	33.9%
Some college, no degree	43,523,572	21.3%	1,612,622	20.9%	10,050	20.2%	5,826	21.6%
Associate's degree	15,733,873	7.7%	594,124	7.7%	4,329	8.7%	2,373	8.8%
Bachelor's degree	36,576,147	17.9%	1,203,679	15.6%	7,960	16.0%	4,369	16.2%
Graduate or professional degree	21,659,618	10.6%	702,146	9.1%	4,279	8.6%	2,535	9.4%
Percent high school graduate or higher	145,895,916	85.7%	6,805,418	88.2%	45,275	91.0%	24,220	89.8%

Percent bachelor's degree or higher	58,235,765	28.5%	1,905,826	24.7%	12,239	24.6%	6,878	25.5%
Population 25 to 34 years	41,184,290	100%	1,420,955	100%	9,305	100%	5,772	100%
High school graduate or higher	36,036,254	87.5%	1,281,701	90.2%	8,644	92.9%	5,299	91.8%
Bachelor's degree or higher	13,014,236	31.6%	423,445	29.8%	2,866	30.8%	1,755	30.4%
Population 35 to 44 years	41,227,505	100%	1,482,197	100%	9,337	100%	4,906	100%
High school graduate or higher	36,074,067	87.5%	1,360,657	91.8%	8,627	92.4%	4,396	89.6%
Bachelor's degree or higher	13,110,347	31.8%	431,319	29.1%	2,530	27.1%	1,393	28.4%
Population 45 to 64 years	81,252,781	100%	3,178,139	100%	20,134	100%	10,315	100%
High school graduate or higher	71,339,942	87.8%	2,876,216	90.5%	18,785	93.3%	9,562	92.7%
Bachelor's degree or higher	23,400,801	28.8%	778,644	24.5%	5,054	25.1%	2,703	26.2%
Population 65 years and over	40,671,441	100%	1,634,602	100%	10,977	100%	5,978	100%
High school graduate or higher	31,683,053	77.9%	1,286,432	78.7%	9,210	83.9%	4,968	83.1%
Bachelor's degree or higher	8,744,360	21.5%	274,613	16.8%	1,800	16.4%	1,040	17.4%

Table 1-5: Median Earnings by Education Level (Source, ACS 2008-2012)

Subject	United States	Ohio	Hancock County, Ohio	Findlay, Ohio
	Estimate	Estimate	Estimate	Estimate
Total:	35,522	33,895	33,027	31,395
Less than high school graduate	19,642	18,853	20,165	20,417
High school graduate (includes equivalency)	27,607	27,405	30,236	28,848
Some college or associate's degree	33,857	32,352	31,506	30,425
Bachelor's degree	50,096	48,288	45,116	40,667
Graduate or professional degree	66,109	63,109	59,885	54,738

Table 1-6: Selected Economic Characteristics, Findlay, Ohio (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percen
Income and Benefits								
Total households	115,226,802	115,226,802	4,555,709	4,555,709	30,342	30,342	17,373	17,373
Less than $10,000	8,272,970	7.20%	369,756	8.10%	1,888	6.20%	1,466	8.40%
$10,000 to $14,999	6,260,673	5.40%	266,295	5.80%	1,662	5.50%	1,154	6.60%
$15,000 to $24,999	12,309,201	10.70%	530,993	11.70%	3,748	12.40%	2,518	14.50%
$25,000 to $34,999	11,939,777	10.40%	510,545	11.20%	3,452	11.40%	2,066	11.90%
$35,000 to $49,999	15,779,346	13.70%	669,984	14.70%	4,616	15.20%	2,771	16.00%
$50,000 to $74,999	20,929,952	18.20%	860,387	18.90%	6,036	19.90%	3,154	18.20%
$75,000 to $99,999	14,110,448	12.20%	547,470	12.00%	3,865	12.70%	1,914	11.00%
$100,000 to $149,999	14,768,587	12.80%	506,695	11.10%	3,327	11.00%	1,486	8.60%
$150,000 to $199,999	5,510,639	4.80%	161,390	3.50%	1,021	3.40%	415	2.40%
$200,000 or more	5,345,209	4.60%	132,194	2.90%	727	2.40%	429	2.50%
Median household income (dollars)	53,046	(X)	48,246	(X)	49,350	(X)	43,101	(X)
Mean household income (dollars)	73,034	(X)	63,996	(X	62,773	(X)	57,750	(X)
Families	76,595,548	76,595,548	2,962,217	2,962,217	20,365	20,365	10,685	10,685
Less than $10,000	3,532,325	4.60%	154,824	5.20%	891	4.40%	691	6.50%
$10,000 to $14,999	2,452,413	3.20%	97,959	3.30%	508	2.50%	411	3.80%
$15,000 to $24,999	6,193,591	8.10%	232,996	7.90%	1,599	7.90%	1,001	9.40%
$25,000 to $34,999	6,945,806	9.10%	277,611	9.40%	1,890	9.30%	1,056	9.90%
$35,000 to $49,999	10,072,700	13.20%	422,311	14.30%	2,886	14.20%	1,486	13.90%
$50,000 to $74,999	14,782,467	19.30%	624,653	21.10%	4,584	22.50%	2,314	21.70%
$75,000 to $99,999	11,013,771	14.40%	448,297	15.10%	3,317	16.30%	1,628	15.20%
$100,000 to $149,999	12,250,514	16.00%	440,832	14.90%	3,000	14.70%	1,275	11.90%
$150,000 to $199,999	4,729,401	6.20%	144,239	4.90%	981	4.80%	406	3.80%
$200,000 or more	4,622,560	6.00%	118,495	4.00%	709	3.50%	417	3.90%
Median family income (dollars)	64,585	(X)	61,163	(X)	61,756	(X)	56,619	(X)
Mean family income (dollars)	85,065	(X)	76,523	(X)	75,334	(X)	71,806	(X)
Per capita income (dollars)	28,051	(X)	25,857		25,785	(X)	24,845	(X)

1.9 Employment

The 2008-2012 ACS data for Findlay shows that the civilian labor force (16-years of age and over) is 21,799. The unemployment rate (10.2%) is slightly higher than the county (8.50%), state (9.70%), and national averages (9.30%). The largest occupation group is the management, business, science and art occupation which employs 33.4% of the civilian employed population 16 years or older. The largest industry is manufacturing, which employs 24.9% of the civilian employed population 16 years or older. Table 1-7 summarizes the median incomes by occupation of the four geographic levels of interest: the City of Findlay, Hancock County, Ohio, and the United States. Table 1-8 summarizes median salary by occupation in Findlay, Hancock County, Ohio and the United States.

Table 1-7: Selected Economic Characteristics, Findlay, Ohio (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
EMPLOYMENT STATUS								
Population 16 years of age and older	243,810,053	100%	9,138,488	100%	59,684	100%	33,461	100%
In labor force	157,664,311	64.70%	5,880,517	64.30%	40,175	67.30%	21,809	65.20%
Civilian labor force	156,533,205	64.20%	5,869,359	64.20%	40,162	67.30%	21,799	65.10%
Employed	141,996,548	58.20%	5,300,141	58.00%	36,758	61.60%	19,571	58.50%
Unemployed	14,536,657	6.00%	569,218	6.20%	3,404	5.70%	2,228	6.70%
Armed forces	1,131,106	0.50%	11,158	0.10%	13	0.00%	10	0.00%
Not in labor force	86,145,742	35.30%	3,257,971	35.70%	19,509	32.70%	11,652	34.80%
Civilian labor force	156,533,205	100%	5,869,359	100%	40,162	100%	21,799	100%
Percent unemployed	N/A	9.30%	N/A	9.70%	N/A	8.50%	N/A	10.20%
OCCUPATION								
Civilian employed population 16 years and over	141,996,548	100%	5,300,141	100%	36,758	100%	19,571	100%
Management, business, science and arts occupations	50,976,044	35.90%	1,803,448	34.00%	11,912	32.40%	6,540	33.40%
Service occupations	25,311,187	17.80%	936,884	17.70%	5,651	15.40%	3,224	16.50%
Sales and office occupation	35,338,663	24.90%	1,314,054	24.80%	8,300	22.60%	4,461	22.80%
Natural resources, construction, and maintenance occupation	13,186,262	9.30%	420,506	7.90%	3,080	8.40%	1,467	7.50%
Production, transportation and material moving	17,184,392	12.10%	825,249	15.60%	7,815	21.30%	3,879	19.80%
INDUSTRY								
Civilian employed population 16 years and over	141,996,548	100%	5,300,141	100%	36,758	100%	19,571	100%
Agriculture, forestry, fishing and hunting, and mining	2,699,250	1.90%	54,573	1.00%	676	1.80%	133	0.70%
Construction	9,221,878	6.50%	280,669	5.30%	1,737	4.70%	894	4.60%
Manufacturing	15,079,996	10.60%	815,530	15.40%	9,020	24.50%	4,868	24.90%
Wholesale trade	4,018,762	2.80%	147,573	2.80%	985	2.70%	505	2.60%
Retail trade	16,422,596	11.60%	619,582	11.70%	4,501	12.20%	2,445	12.50%
Transportation, warehousing, and utilities	7,096,633	5.00%	258,264	4.90%	1,640	4.50%	753	3.80%
Information	3,139,327	2.20%	96,787	1.80%	418	1.10%	267	1.40%
Finance and insurance, real estate, renting and leasing	9,574,851	6.70%	344,229	6.50%	1,286	3.50%	632	3.20%
Professional scientific, management, administrative, and waste management services	15,141,136	10.70%	485,655	9.20%	2,672	7.30%	1,578	8.10%
Educational services, health care, and social assistance	32,513,621	22.90%	1,282,221	24.20%	8,002	21.80%	4,046	20.70%
Arts, entertainment, recreation, accommodation and food services	13,039,332	9. 20%	460,134	8.70%	3,348	9.10%	2,119	10.80%
Other services, except public administration	7,027,803	4.90%	242,046	4.60%	1,603	4.40%	904	4.60%
Public administration	7,021,363	4.90%	212,878	4.00%	870	2.40%	427	2.20%

Table 1-8: Median Salary by Occupation (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio	
	Total	Median earnings (dollars)	Total	Median earnings (dollars)	Total	Median earnings (dollars)
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
Civilian employed population 16 years and over	141,996,548	33,216	5,300,141	31,974	36,758	31,124
Management, business, science, and arts occupations:	50,976,044	53,388	1,803,448	50,947	11,912	48,887
Management, business, and financial occupations:	20,391,092	60,417	712,810	55,898	5,366	53,778
Management occupations	13,708,597	63,943	476,988	60,196	3,467	53,456
Business and financial operations occupations	6,682,495	54,141	235,822	51,248	1,899	54,406
Computer, engineering, and science occupations:	7,444,293	69,032	247,594	63,183	1,436	56,574
Computer and mathematical occupations	3,571,107	71,737	115,462	65,103	536	54,690
Architecture and engineering occupations	2,640,485	71,811	94,954	64,719	628	58,221
Life, physical, and social science occupations	1,232,701	54,619	37,178	50,770	272	58,571
Education, legal, community service, arts, and media occupations:	15,348,288	40,837	513,478	39,615	3,036	33,839
Community and social services occupations	2,357,690	37,799	86,268	36,671	480	32,895
Legal occupations	1,662,029	72,663	49,533	62,721	193	62,063
Education, training, and library occupations	8,660,533	39,599	303,811	40,016	1,844	37,711
Arts, design, entertainment, sports, and media occupations	2,668,036	36,269	73,866	32,904	519	30,711
Healthcare practitioner and technical occupations:	7,792,371	53,171	329,566	48,779	2,074	46,491
Health diagnosing and treating practitioners and other technical occupations	5,333,656	63,501	221,239	56,906	1,308	51,250
Health technologists and technicians	2,458,715	35,715	108,327	33,024	766	32,252
Service occupations:	25,311,187	17,464	936,884	15,476	5,651	12,110
Healthcare support occupations	3,505,347	21,982	160,125	20,030	803	16,563
Protective service occupations:	3,172,920	41,694	100,685	43,165	349	32,868
Fire fighting and prevention, and other protective service workers including supervisors	1,741,974	29,709	57,075	28,250	206	30,802
Law enforcement workers including supervisors	1,430,946	54,486	43,610	52,285	143	46,328
Food preparation and serving related occupations	7,964,748	13,123	322,186	10,709	2,620	8,934
Building and grounds cleaning and maintenance occupations	5,638,696	18,037	192,144	17,872	1,072	17,368
Personal care and service occupations	5,029,476	14,962	161,744	14,121	807	14,460
Sales and office occupations:	35,338,663	28,156	1,314,054	27,033	8,300	26,572
Sales and related occupations	15,652,899	26,794	551,648	25,516	3,372	23,978
Office and administrative support occupations	19,685,764	28,870	762,406	27,697	4,928	27,592
Natural resources, construction, and maintenance occupations:	13,186,262	33,768	420,506	36,539	3,080	35,343
Farming, fishing, and forestry occupations	1,031,520	18,221	18,235	17,055	153	8,523
Construction and extraction occupations	7,435,626	32,133	225,921	34,413	1,396	34,313
Installation, maintenance, and repair occupations	4,719,116	40,629	176,350	41,091	1,531	39,035
Production, transportation, and material moving occupations:	17,184,392	29,680	825,249	30,777	7,815	31,235
Production occupations	8,554,786	31,104	449,018	32,726	4,216	31,994
Transportation occupations	5,051,632	32,331	196,531	31,503	1,411	30,060
Material moving occupations	3,577,974	21,948	179,700	23,844	2,188	29,931

1.10 Journey to Work

Commuting characteristics are depicted in Table 1-9. The proportion of workers who drive to work by themselves within Findlay, Ohio was higher than in the United States as a whole (82.2% versus 76.1% respectively), and the proportion who carpooled (9.6%) was lower than the national average (10%). Public transportation use within Findlay (0.2%) is dramatically lower than the national average (5%). Additionally, 3.4% of occupied households had no vehicles available versus 4.4% nationally. Average travel time to work in Findlay is less than 15 minutes. This commute time is lower than county (17 minutes), state (23 minutes), and national (25 minutes) averages

Table 1-9: Selected Commuting Characteristics, Findlay, Ohio (Source, ACS 2008-2012)

Subject	United States		Ohio		Hancock County, Ohio		Findlay, Ohio	
	Estimate	Percent	Estimate	Percent	Estimate	Percent	Estimate	Percent
Workers 16 and over	139,893,639	100%	5,196,293	100%	35,953	100%	19,174	100%
Means of Transportation to work								
Car, truck, or van	120,588,317	86.2%	4,754,608	91.5%	33,292	92.6%	17,602	91.8%
Drove alone	106,459,059	76.1%	4,318,119	83.1%	30,093	83.7%	15,761	82.2%
Carpooled	13,989,364	10.0%	431,292	8.3%	3,200	8.9%	1,841	9.6%
In 2-person carpool	10,771,810	7.7%	348,152	6.7%	2,481	6.9%	1,496	7.8%
In 3-person carpool	1,818,617	1.3%	46,767	0.9%	539	1.5%	249	1.3%
In 4-or-more person carpool	1,259,043	0.9%	36,374	0.7%	180	0.5%	96	0.5%
Workers per car, truck, or van	1.07	N/A	1.05	N/A	1.06	N/A	1.06	N/A
Public transportation (excluding taxicab)	6,994,682	5.0%	88,337	1.70%	72	0.2%	35	0.2%
Walked	3,917,022	2.8%	119,515	2.30%	863	2.4%	563	3.2%
Bicycle	839,362	0.6%	15,589	0.30%	144	0.4%	140	0.8%
Taxicab, motorcycle, or other means	1,678,724	1.2%	41,570	0.80%	252	0.7%	140	0.8%
Worked at home	6,015,426	4.3%	181,870	3.50%	1,294	3.6%	563	3.2%
Travel time to work								
Workers who did not work at home	133,916,010	100%	5,016,561	100%	34,646	100%	18560	100%
Less than 10 minutes	18,346,493	13.7%	752,484	15.0%	8,835	25.50%	5,958	32.1%
10 to 14 minutes	19,283,905	14.4%	767,534	15.3%	8,488	24.50%	5,735	30.9%
15 to 19 minutes	20,756,982	15.5%	812,683	16.2%	6,340	18.30%	2,970	16.0%
20 to 24 minutes	19,819,569	14.8%	822,716	16.4%	4,261	0.123	1,262	6.8%
25 to 29 minutes	8,168,877	6.1%	381,259	7.6%	1,420	4.10%	278	1.5%
30 to 34 minutes	18,212,577	13.6%	627,070	12.5%	2,044	5.90%	761	4.1%
35 to 44 minutes	8,570,625	6.4%	311,027	6.2%	901	2.60%	445	2.4%
45 to 59 minutes	10,043,701	7.5%	290,961	5.8%	1,317	3.80%	724	3.9%
60 or more minutes	10,847,197	8.1%	245,811	4.9%	1,005	2.90%	408	2.2%
Mean travel time to work (minutes)	25.4	N/A	23	N/A	17.1	N/A	14.8	N/A
Vehicles Available								
Workers 16 years and over in households	138,493,582	100%	5,146,991	100%	35,627	100%	18,858	100%
No vehicle available	6,093,718	4.4%	149,263	2.9%	784	2.2%	641	3.4%
1 vehicle available	29,637,627	21.4%	1,029,398	20.0%	5,985	16.8%	4,300	22.8%
2 vehicles available	58,582,785	42.3%	2,259,529	43.9%	16,282	45.7%	8,863	47.0%
3 or more vehicles available	44,179,453	31.9%	1,713,948	33.3%	12,576	35.3%	5,073	26.9%

2.0 Economic Framework

This appendix documents the National Economic Development analyses conducted for the Blanchard River Watershed Study. The analysis follows the framework and methodology as directed by the USACE Planning Guidance Notebook (ER 1105-2-100) dated 22 April 2000 and The Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies dated 10 March 1983. Alternative plans evaluated for flood risk management include diversion channels, levees/floodwalls, and nonstructural measures.

The FY15 discount rate of 3.375% (EGM 15-01) is utilized for present value calculation. Costs and benefits are expressed in November 2014 prices and a 50-year planning period is assumed.

This analysis incorporates risk and uncertainty as directed by ER 1105-2-101, Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies (1 March 1996) and EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (August 1996). Uncertainty is inherent in all economic related input variables used in a typical flood damage analysis whether they may be LiDAR originated ground elevations, first floor elevations determined by "windshield survey", valuation of structures, generic depth-damage functions, content values based on content-structure value ratios, or assignment of occupancy type to structures for purposes of depth-damage calculations. Key hydrologic and hydraulic inputs such as frequency-discharge and stage-discharge relationships also possess their own elements of uncertainty.

Whether an alternative is economically justified is determined by comparing expected annual benefits to average annual costs. If expected annual benefits for an alternative exceed the average annual costs, then the alternative is considered economically justified. The plan with the largest average annual net benefits is the NED plan. All plans with positive average annual benefits will yield a benefit-to-cost ratio (BCR) greater than or equal to 1.0.

The analyses of without-project and with-project damages include damages or costs incurred from a range of categories. Categories considered in the economic analysis are: damages to structures and contents, damages to automobiles, increased emergency response expenditures, evacuation and subsistence expenditures, reoccupation costs, and costs for commercial cleanup and restoration. These categories are intended to capture a substantial portion of the financial burden incurred by a flood event; however, they are not comprehensive enough to capture every cost or damage that could result from flooding in the area. Transportation and agricultural damages have not been quantified to date, but will be included in the economic analysis prior to release of the Final Detailed Project Report (see sections 2.5.5 and 2.5.6 for details).

Generally, flood damages increase as flood frequency decreases; they are typically higher for the 0.01% flood compared to the 50% flood. Damages by flood frequency are paramount from the economic perspective since flood damages are average annualized based on probability of flood occurrence.

To estimate expected annual damages (EADs) from flooding, eight flooding events were modeled, representing a range of recurrence probabilities from a 50-percent-chance (2-year) flood event to 0.2-percent-chance (500-year) flood event.

This section discusses the types of evaluations and methods used in the economic analysis.

2.1 Hydrologic and Hydraulic Modeling

Refer to H&H Appendix A for additional details.

2.2 Damage Reaches

The streams in the study area were divided into reaches based on existing features (e.g., bridges) and the extent of proposed alternatives (Figure 2-1and Table 2-1). Dividing the streams into reaches provided the ability to more accurately assess the impacts of proposed alternatives and to focus the analysis on specific areas.

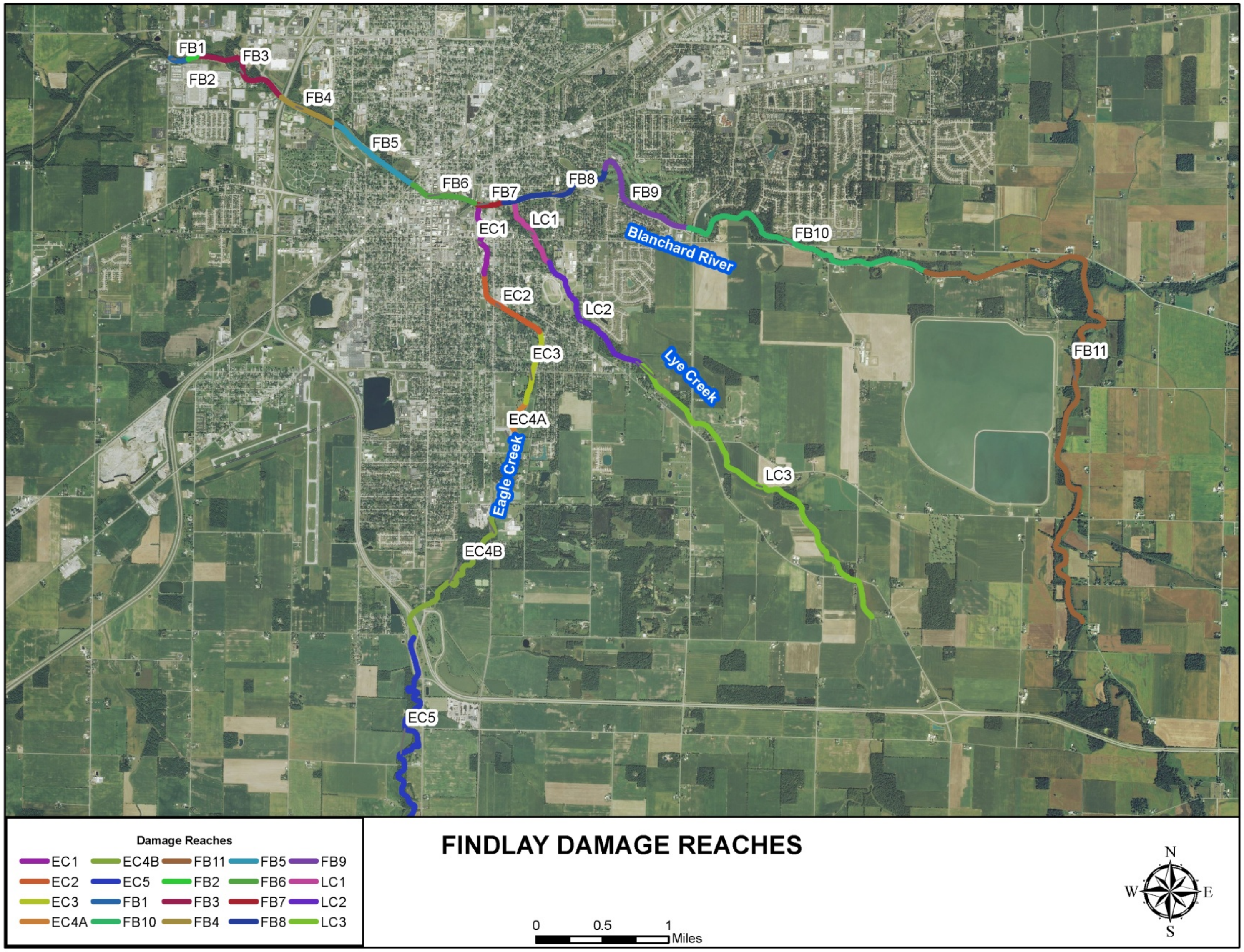


Figure 2-1: Findlay Damage Reaches

Reaches were also assigned index locations as a point of reference for uncertainty analysis and development of the stream profiles. The index locations were selected by professionals conducting the H&H analysis based on locations that were considered representative of the characteristics of the reaches and where there was the least amount of uncertainty in the model results, such as near a gauge station. For this study, selected reaches were further delineated by either the right or left bank of the stream. Table 2-1 and Figure 2-1 show a breakdown of the streams, reaches, and index locations for Findlay.

Table 2-1: Findlay Streams, Reaches, and Index Locations

Stream Name	Reach Name	Beginning Station	Ending Station	Index Station
Blanchard				
	FB1	283148	283893	283300
	FB2	283893	284000	283950
	FB3	284000	288600	286300
	FB4R	288600	290843	289505
	FB4L	288600	290843	289505
	FB5R	290843	294930	292914
	FB5L	290843	294930	292914
	FB6R	294930	297591	296168
	FB6L	294930	297591	296168
	FB7	297591	299000	298205
	FB8	299000	303732	300071
	FB9R	303732	308675	304863
	FB9L	303732	308675	304863
	FB10R	308675	319573	314100
	FB10L	308675	319573	314100
	FB11	319573	343598	323019
Eagle Creek				
	EC1R	207	3051	1616
	EC1L	207	3051	1616
	EC2R	3051	6500	4824
	EC2L	3051	6500	4824
	EC3R	6500	9422	8019
	EC3L	6500	9422	8019
	EC4aR	9422	12263	11985
	EC4aL	9422	12263	11985
	EC4bR	12263	21642	17612
	EC4bL	12263	21642	17612
	EC5	21642	34011	23974
Lye Creek				
	LC1	72	2833	1442
	LC2	2833	8886	5246
	LC3	8886	23557	14408

2.3 Structures, Contents, and Automobiles

Damages to structure, contents, and automobiles account for the majority of damages that result from a flood event. These categories provide the foundation for the economic evaluation of the alternatives. USACE proposes alternatives with these damages in mind; the goal of plan formulation is to minimize these flood impacts in a way that is consistent with protecting the nation's environment. The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software was used to estimate damages to structures, contents, and automobiles for without-project and with-project alternatives. The following sections provide details on how damages were estimated.

2.3.1 Structure Inventory

Knowledge of existing residential and nonresidential development located in a floodplain is essential when evaluating flood-risk-management alternatives. Findlay's structure inventory comprises all residential and nonresidential structures within the 1.0 % exceedance event (100-year floodplain) generated by United Research Services (URS) and additional structures located in areas that could potentially experience induced flooding which were determined via H&H expert elicitation.
URS is an Architect/Engineering (AE) firm that has assisted with data collection and analysis throughout this study.

Following the 2007 flood event, multiple structures have been purchased for flood mitigation via grants funded by the City of Findlay, Hancock County, and Northwest Ohio Flood Mitigation Partnership. A list of purchased structures was provided by Hancock County, subsequently, these structures were removed from the inventory since they no longer exist in the floodplain.

There are 5,226 structures included in the HEC-FDA model for Findlay OH: 4,567 residential (87%), 549 commercial (11%), 103 public (2%) and 7 industrial (<1%). This structure breakdown is depicted in Table 2-2 and Figure 2-3.

Table 2-2: Findlay Structure Inventory

Structure Type	Structure Count	Percent of Total
Residential:	4,567	87%
Commercial:	549	11%
Public:	103	2%
Industrial:	7	<1%
TOTAL:	**5,226**	**100%**

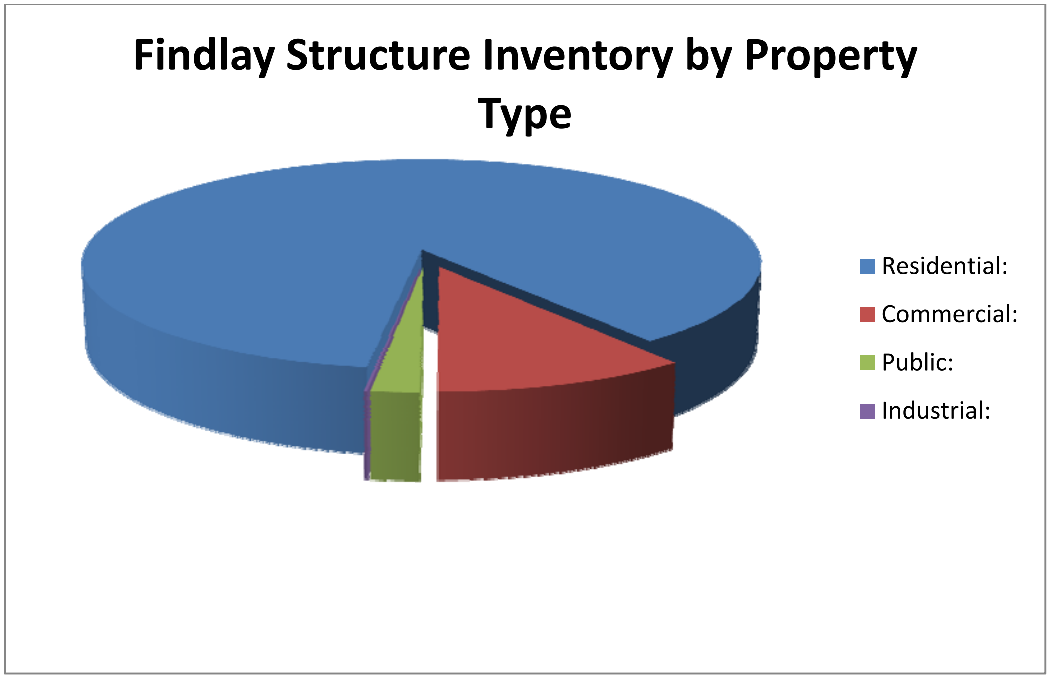


Figure 2-2: Findlay Structure Inventory by Property Type

There are 4,567 residential structures included in the HEC-FDA model for Findlay OH: 1,660 one-story without basements (36%), 1,279 one-story with basements (28%), 1,079 two-plus stories with basements (24%), 399 two-plus stories without basements (9%), 88 split levels without basements (2%), and 62 split levels (1%) with basements. This residential structure occupancy type breakdown is displayed in Figure 2-3.

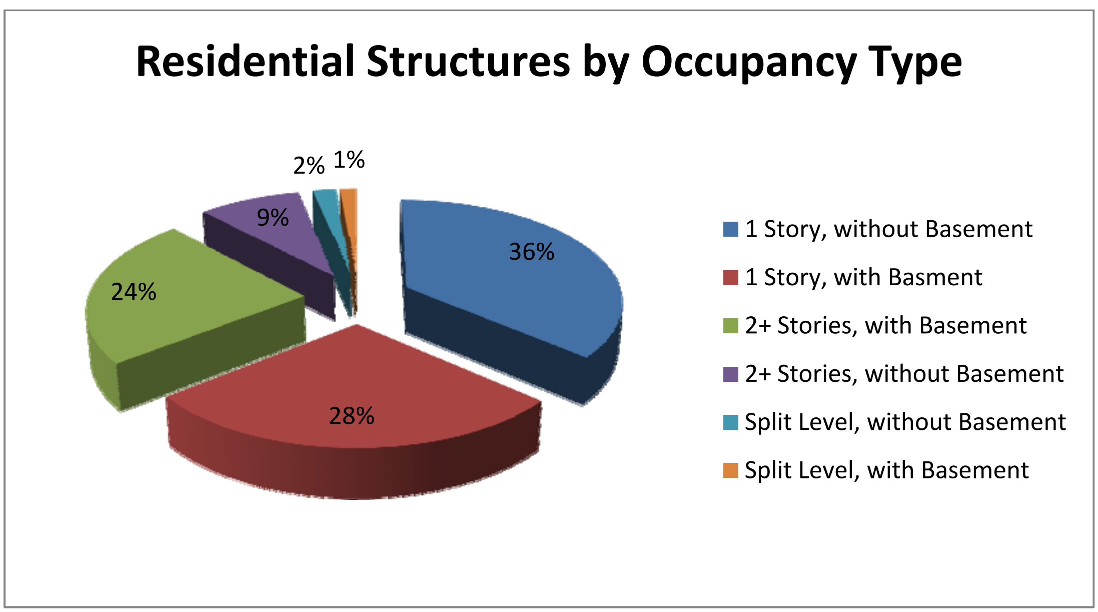


Figure 2-3: Residential Structures by Occupancy Type

Specific building attributes were tabulated for each structure, including a unique structure name, parcel ID, latitude/longitude, structure type, structure/content value, stream and bank side on which the structure is located, approximate stream station location, depth damage function (DDF), first floor elevation (FFE), ground elevation and begin damage elevation.

Structure Location

The locations of the structures were determined using a GIS parcel shapefile obtained from Hancock County assessors. This file contained parcel boundaries, which were used to locate the structures. The center of the parcel was assumed to be representative of the location of the structure. In some cases, such as irregularly shaped parcels, the location of the structure was adjusted using satellite images and GIS.

The structures were assigned to a stream based on their location in the study area. The stream that was adjacent to the structure was typically assigned. In cases where it was not clear which stream to assign (e.g., structure located at the confluence of two streams), professional judgment was used to assign the stream based on which stream was most representative of the flood characteristics for that structure. The structures in Findlay were assigned to one of three streams: Blanchard River, Eagle Creek, and Lye Creek.

Stream stations which correspond to those used in H&H modeling were imported into Arc-GIS and used to match each structure to a stream station. The assigned station was the closest point where the structure was perpendicular to the stream.

Figure 2-4 displays the structure locations of all 5,226 structures included in the HEC-FDA model. Figure 2-5 and Figure 2-6 display the locations of residential and non-residential structures.

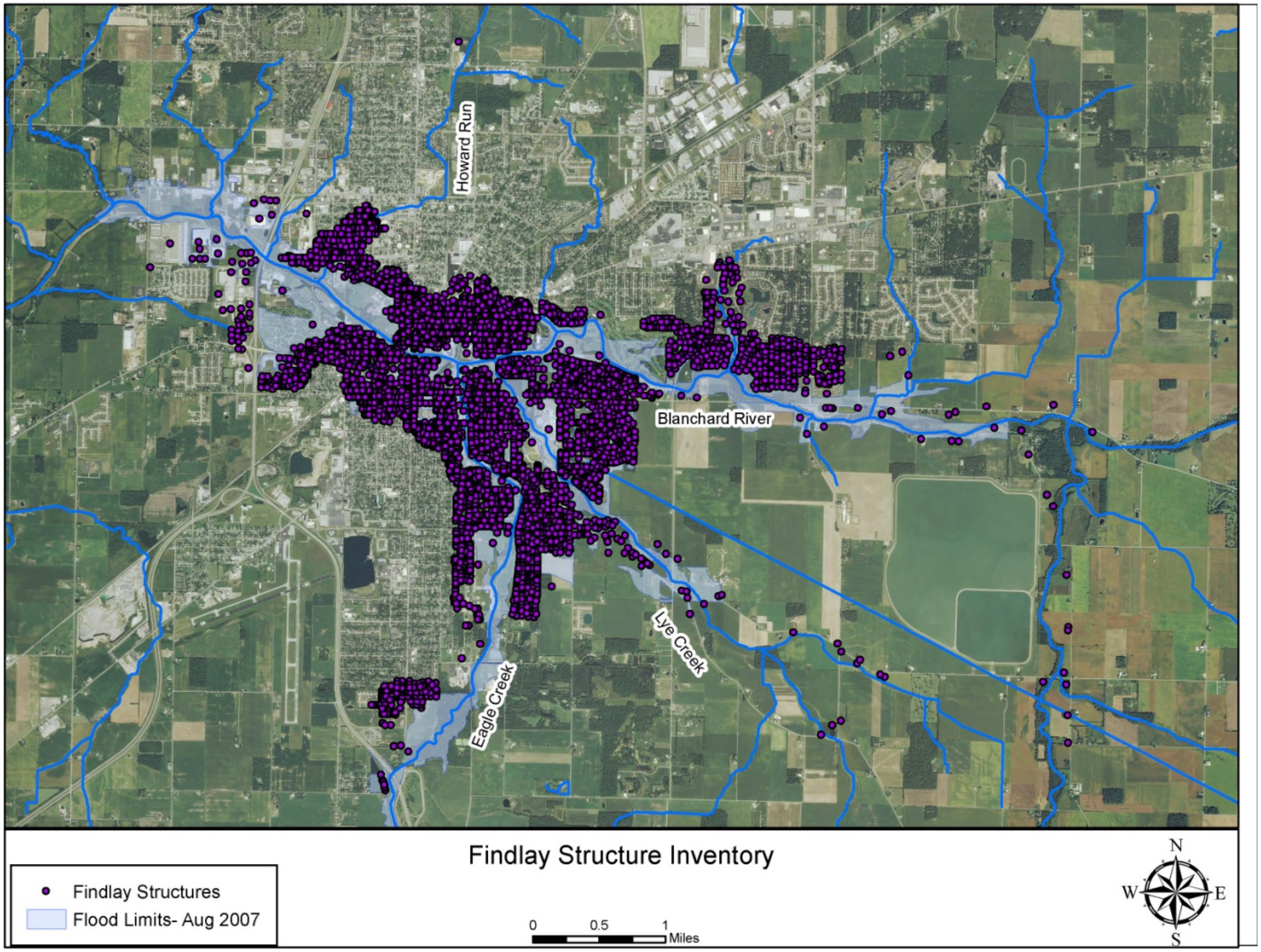


Figure 2-4: Findlay Structure Inventory

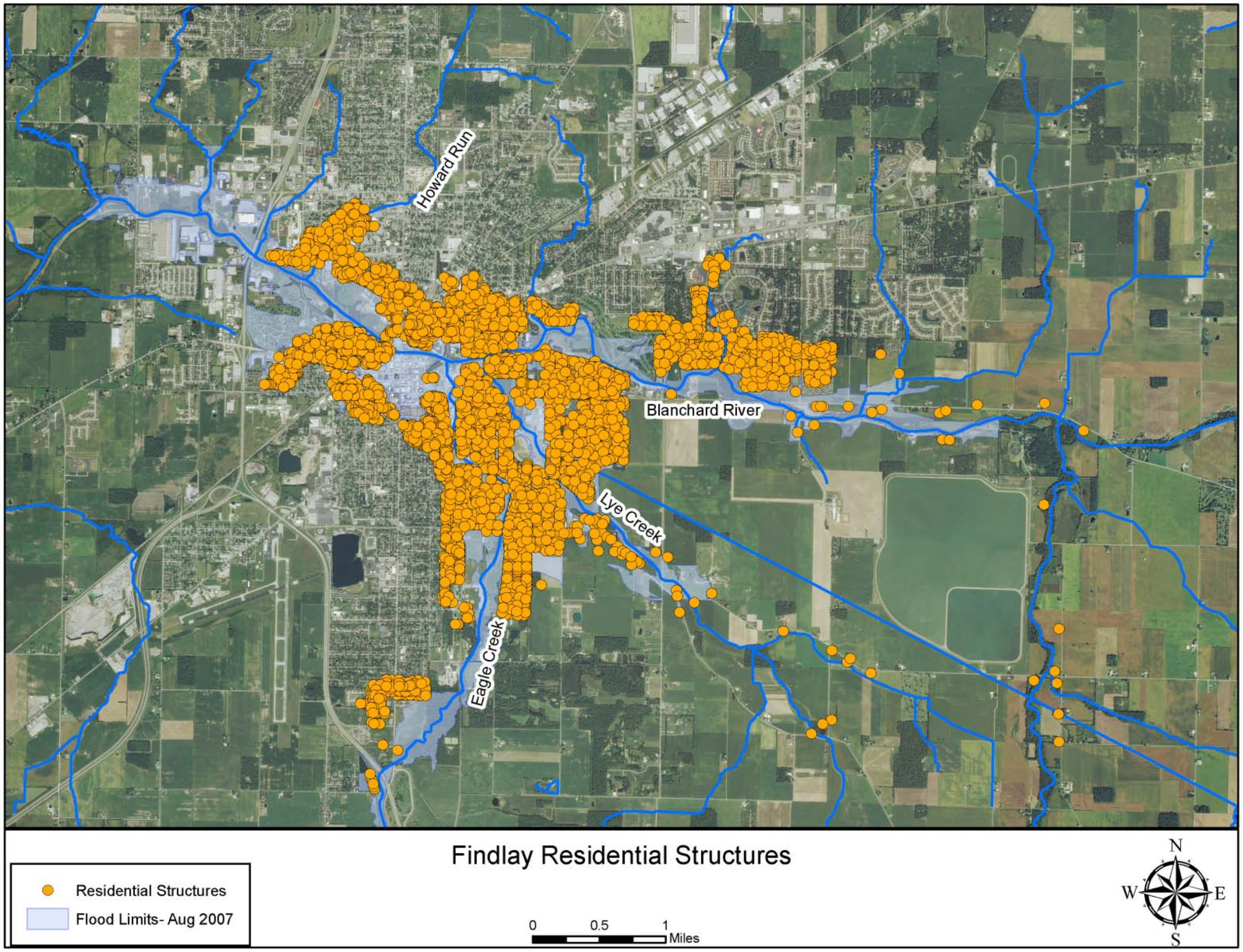


Figure 2-5: Findlay Residential Structures

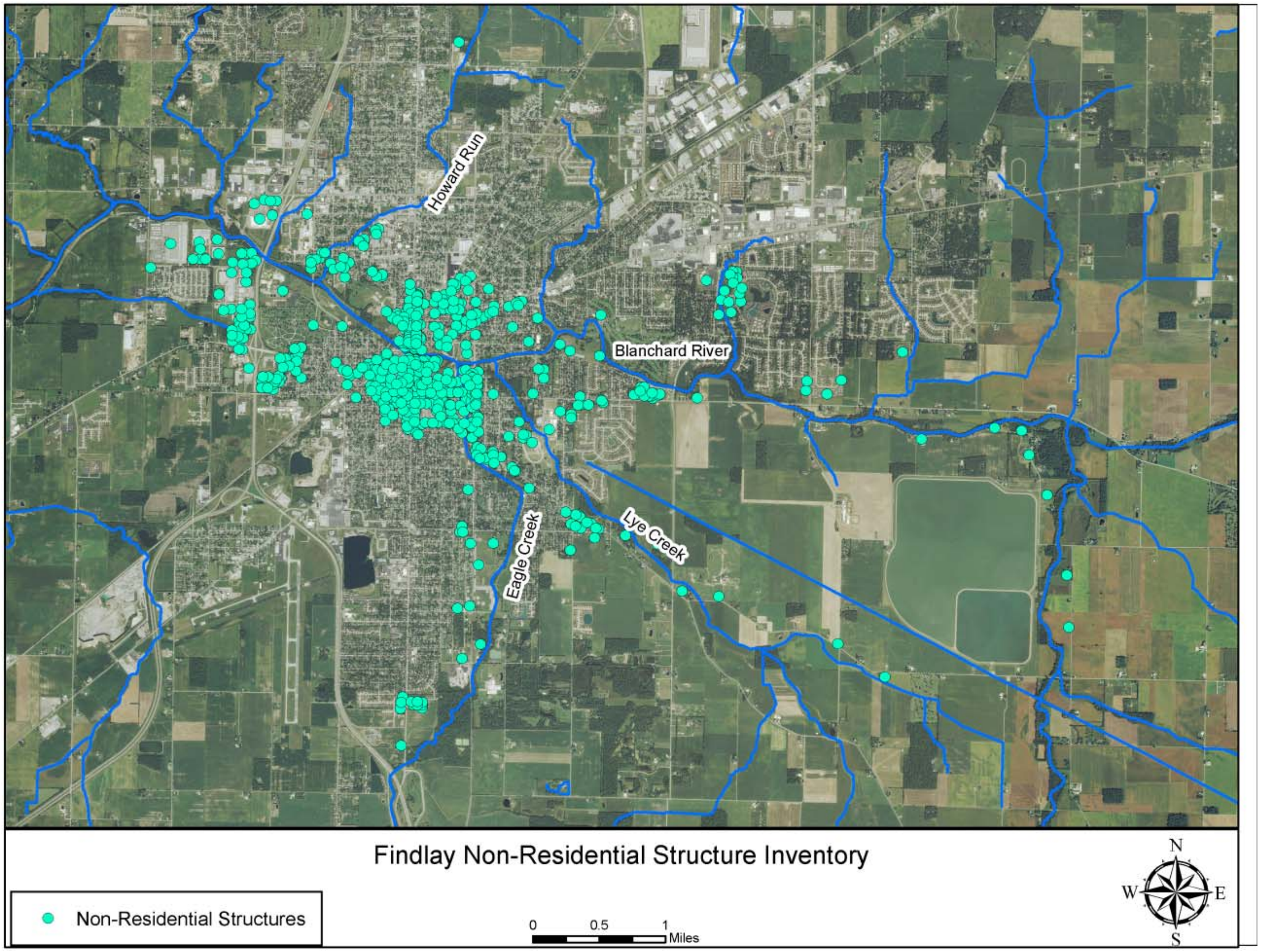


Figure 2-6: Findlay Non-Residential Structures

Structure Elevation

The FFE (First Floor Elevation) for each structure was determined from two data points: the elevation of the adjacent grade (ground elevation) to the structure and the height of the first floor relative to the ground.

The adjacent grade elevation of each structure was determined using a parcel shapefile with structure locations (denoted as points) and a LiDAR digital elevation map obtained from the Natural Resources Conservation Service (NRCS). Using ArcGIS, digital elevation maps were created to estimate the ground elevation throughout the study area. Since the study area is very flat, it was assumed the ground elevation surrounding a structure was a consistent height. Therefore, grade at each structure was used to represent the adjacent ground elevation.

Field observations were used to estimate the height of the first floor of the structure above the adjacent grade. Surveyors established the point representing the adjacent grade, and estimated the distance up to the bottom of the front door of the structure. The numbers of steps leading to the first floor entrance were counted to serve as an estimation of FFE adjustment. Each step represented eight inches of adjustment. The local sponsor estimated the height of the first floor above the adjacent grade for all structures within the 2007 flood boundary. Average characteristics of the inventoried structures were used to assign the height above ground for structures that were not sampled.

The elevation of the adjacent grade and the height of the first floor above the adjacent grade were added together to estimate the FFE. Since most structures in the study area are damaged by overland flooding, the begin damage point for each structure was assumed to be the elevation of the adjacent grade. HEC-FDA uses the begin damage point to estimate the water elevation that could start to impact a structure. If the begin damage point is not entered, HEC-FDA would begin to estimate damages beginning from the bottom of the depth-damage function assigned to a structure. For overland flooding, flood water would not be anticipated to impact a structure until water reached the structure. For structures with basements, it would be anticipated that floodwater would enter the structure and fill the basement through a window or other low-hole opening. Therefore, the begin damage point was set at the adjacent grade to avoid overestimating damages, especially to structures with basements.

Depreciated Replacement Value

Hancock and Putnam County tax assessors provided value data for residential and non-residential structures in the study area. The tax assessor data listed multiple valuation components (e.g., land, improvement) for each parcel that could be used to represent the value of structures in the study area. To ensure compliance with USACE guidance requiring the use of depreciated replacement values for structures, a random sample of the structures were valued using RSMeans[1], a commercially available valuation method for comparison to the tax assessor valuations.

[1] Replacement costs were estimated using the model approach provided in the RSMeans Square Foot Costs book (2012). The replacement values were adjusted for depreciation using ratios developed for the USACE Institute for Water Resources.

A field inventory of 10% of the structures in the study area was conducted to collect characteristics of the structures, such as size, condition, quality, roofing material, etc. The characteristics are input variables used to estimate the replacement value using RSMeans. The replacement values were adjusted for depreciation using ratios developed by the Institute for Water Resources (IWR). The depreciated replacement values calculated for the sample of inventoried structures were compared to tax assessor values to determine if a relationship between the data sets could be identified. However, there was great variance between the data sets and a relationship could not be identified. Because of the impact that nonresidential structures can have on the results of a flood risk management study and because there were relatively few nonresidential structures in the study area, a second field inventory was conducted to inventory the remaining nonresidential structures. The remaining nonresidential structures were also valued using RSMeans and depreciated. These values were used for the economic analysis of nonresidential structures.

The values for the residential structures were estimated based on the characteristics of the random sample that was completed. From the random sample, an average dollar per square foot value was estimated based on the structure type (e.g., one-story, two-story). The average dollar per square foot value was then applied to each residential structure in the study area based on the size and characteristics from the tax assessor database. While individual structures may not be as accurate using this, it should provide a reasonable overall estimate of the study area.

Depreciated replacement values were surveyed in October 2012 prices. These values were updated to November 2014 prices for the current analysis using the Civil Works Construction Cost Index System (CWCCIS – EM 111-2-1304) composite index. This update yields a 4% increase in structure inventory values. Figure 2-7 and Figure 2-8 show the estimated depreciated replacement value of residential and non-residential structures in Findlay.

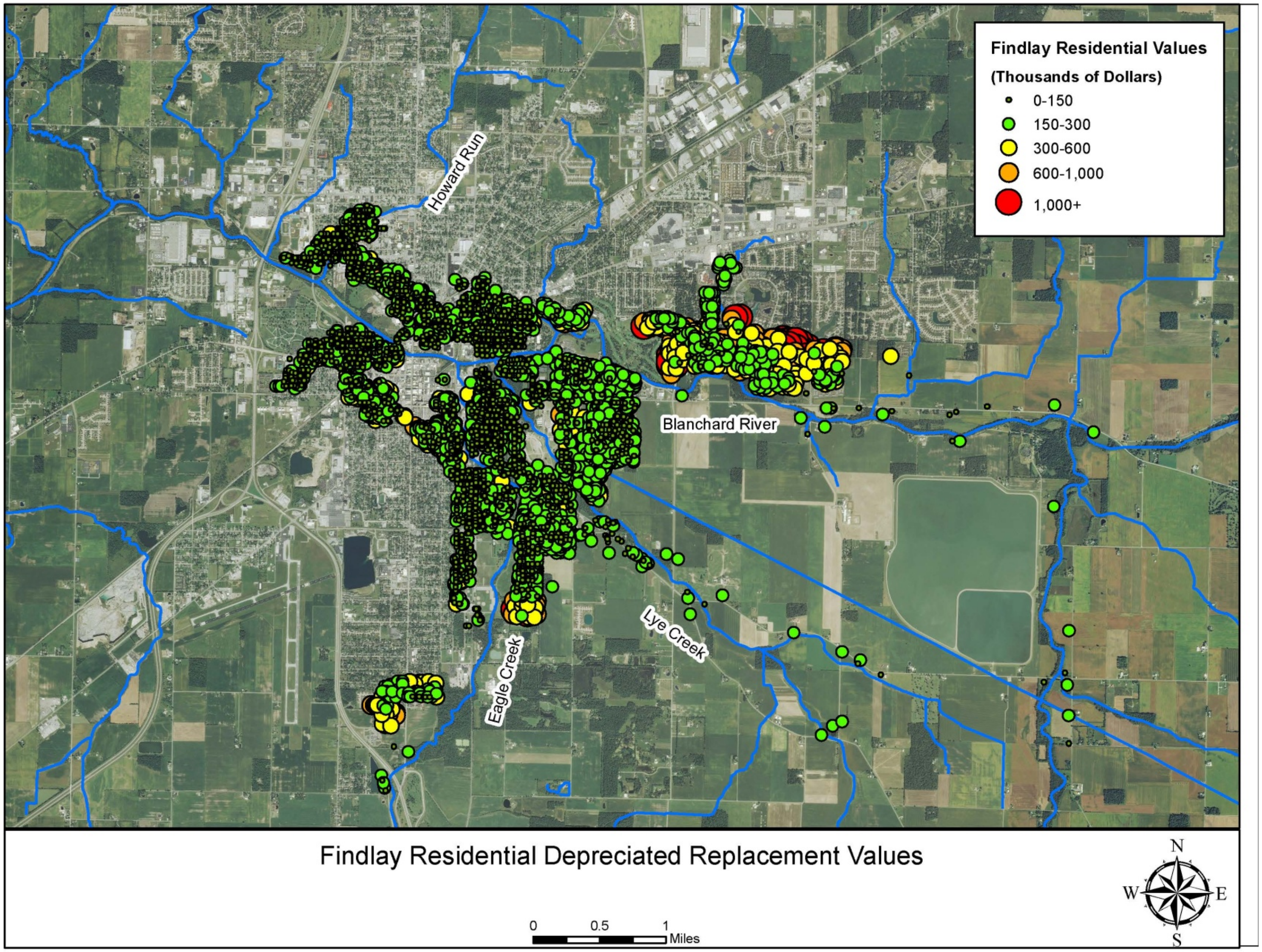


Figure 2-7: Residential Depreciated Replacement Values

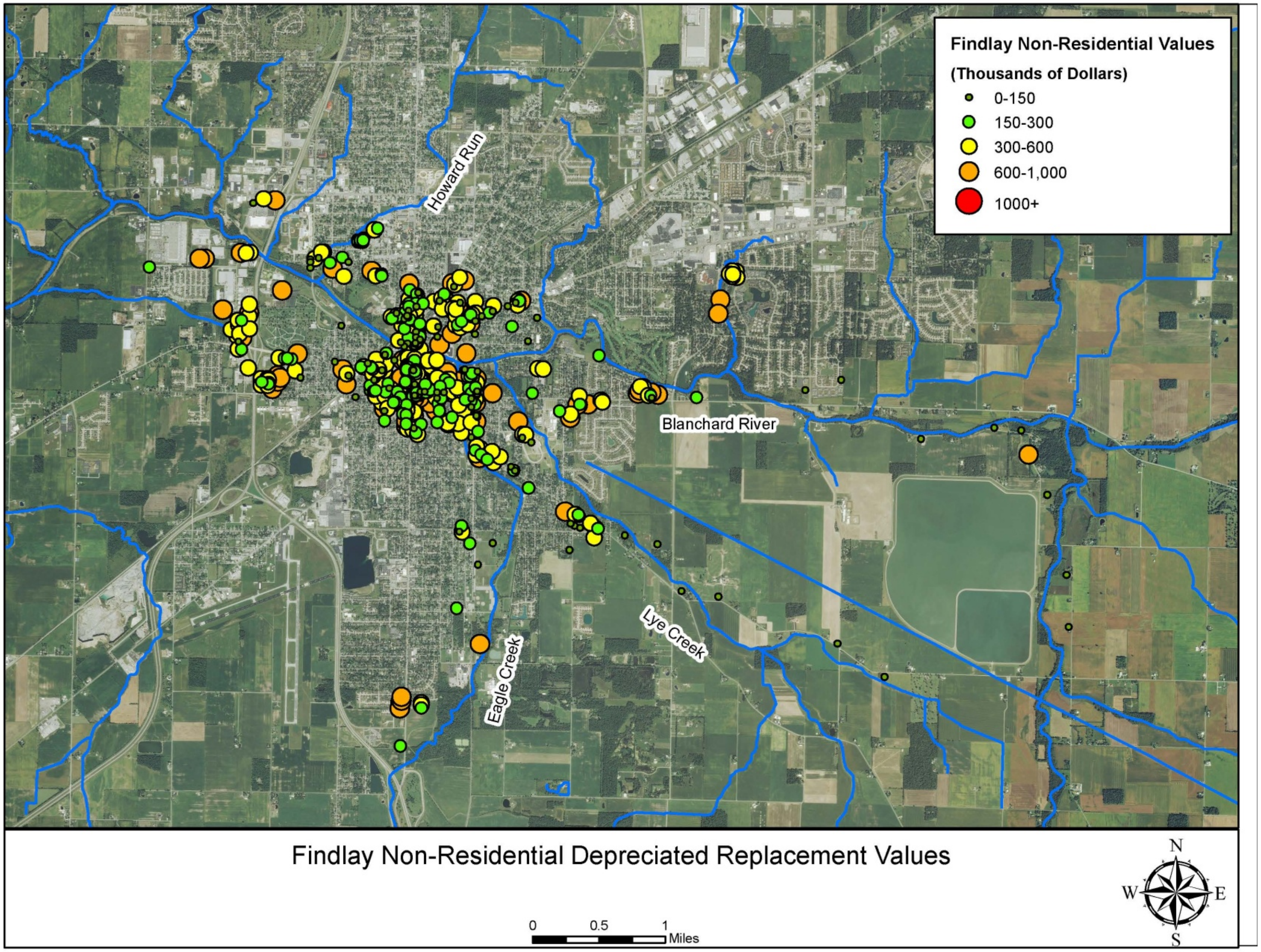


Figure 2-8: Non-Residential Depreciated Replacement Values

Depth-Damage Functions

Each structure was assigned a depth damage function (DDF) that estimates an economic loss as a percentage of the value of the structure or contents based on the depth of flooding. The DDFs used in this study were obtained from four sources: Economic Guidance Memorandum (EGM) 04-01 Generic Depth-Damage Relationships for Residential Structures, EGM 09-04 Generic Depth-Damage Relationships for Vehicles, building specific commercial damage surveys (See Attachment A - Commercial and Industrial Flood Damage Survey), and generic curves obtained from USACE Galveston District.

Residential Structures:

All structure and content DDFs assigned to residential structures were developed by IWR as referenced in EGM 04-01. These DDFs are considered generic and are appropriate for use throughout the United States. The DDFs are divided into multiple categories based on the type of structure (e.g., one-story, two-story, foundation type), with separate DDFs to represent damages to the structure and the contents. The DDFs were assigned to each structure based on information contained in the tax assessor databases (e.g., number of floors, presence of basement).

Non-Residential Structures:

All structure DDFs assigned to non-residential structures were obtained from the USACE Galveston District. The appropriate DDFs were selected from available USACE Galveston District based on the type and the use of the structure.

A portion of the DDFs assigned to nonresidential structures were developed based on personal interviews with business owners and operators. The interviews were conducted by the local sponsor in 2010 using a questionnaire that was approved by the Office of Management and Budget. This questionnaire is included as reference in Attachment A - Commercial and Industrial Flood Damage Survey. The survey asked respondents to estimate a value of the structure's contents for three categories (equipment, furniture, and inventory/products) and to estimate the percentage or dollar value that would be lost at various increments of flooding. For percentage or dollar value damages, a low, high, and most likely estimate was requested. Some larger businesses or those who had suffered significant historical flooding were able to provide far greater detail than businesses without a history of flooding.

The data from the interviews was used to develop a unique DDF for each business where an interview was conducted. The unique DDFs were calculated by multiplying the total value of the contents for each category by the percent damage at each level of inundation. The estimated damages for the three categories (equipment, furniture, and inventory/products) were aggregated by depth to estimate the total damage at each level of flooding.

However, there were a number of nonresidential structures where interviews were not conducted due to revisions in the study area or interviews that could not be completed. For structures where interviews were not completed, generic nonresidential DDFs from the previously mentioned

EGMs were used. The structures were assigned an appropriate DDF based on the type and use of the structure.

Residential and Non-Residential Structures:

In cases where multiple structures were located on a single parcel, the data on the individual structures from the interviews were combined to form a single DDF. Therefore, each entry in HEC-FDA is representative of the damages that would occur for that parcel - not necessarily each structure on the parcel.

The content-to-structure-value ratios (CSVRs) for all of the structures were incorporated into the analysis based on the assigned DDF and interview data.

Residential, non-residential, and automobile DDF references are given in Table 2-3.

Table 2-3: Depth Damage Function References

DDF Type	Structural Value Reference	Content Value Reference
Residential Structures	EGM 04-01, Generic Depth-Damage Relationships for Residential Structures	EGM 04-01, Generic Depth-Damage Relationships for Residential Structures
Non-Residential Structures	Generic DDF developed by USACE Galveston District	Non-Residential Damage Surveys
Automobiles	EGM 09-04 -Generic Depth-Damage Relationships for Vehicles	EGM 09-04 -Generic Depth-Damage Relationships for Vehicles

Table 2-4, Figure 2-9, and Figure 2-10 provide an example of structure and content depth damage curves used for residential one story structures with basements (EGM 04-01).

Table 2-4: Residential Structure and Content Depth Damage Curves

Structural Depth Damage Curve

Residential - One Story Structure, With Basement (1ST-B)		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-8	0	0.00
-7	0.7	1.34
-6	0.8	1.06
-5	2.4	0.94
-4	5.2	0.91
-3	9	0.88
-2	13.8	0.85
-1	19.4	0.83
0	25.5	0.85
1	32	0.96
2	38.7	1.14
3	45.5	1.37
4	52.2	1.63
5	58.6	1.89
6	64.5	2.14
7	69.8	2.35
8	74.2	2.52
9	77.7	2.66
10	80.1	2.77
11	81.1	2.88
12	81.1	2.88
13	81.1	2.88
14	81.1	2.88
15	81.1	2.88
16	81.1	2.88

Content Depth Damage Curve

Residential - One Story Structure, With Basement (1ST-B)		
Depth	**Mean of Damage**	**Standard Deviation of Damage**
-8	0.1	1.60
-7	0.8	1.16
-6	2.1	0.92
-5	3.7	0.81
-4	5.7	0.78
-3	8	0.76
-2	10.5	0.74
-1	13.2	0.72
0	16	0.74
1	18.9	0.83
2	21.8	0.98
3	24.7	1.10
4	27.4	1.39
5	30	1.60
6	32.4	1.81
7	34.5	1.99
8	36.3	2.13
9	37.7	2.25
10	38.6	2.35
11	39.1	2.45
12	39.1	2.45
13	39.1	2.45
14	39.1	2.45
15	39.1	2.45
16	39.1	2.45

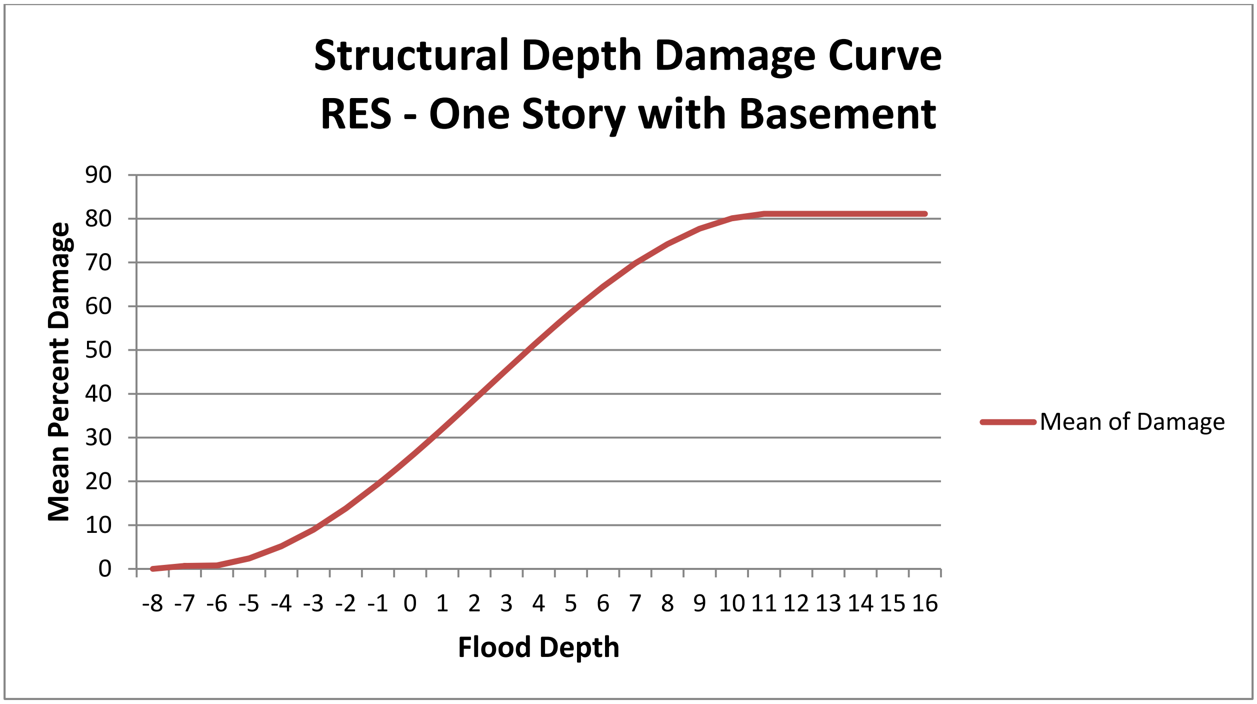


Figure 2-9: Structure Depth-Damage Curve – Residential, One-Story, With Basement

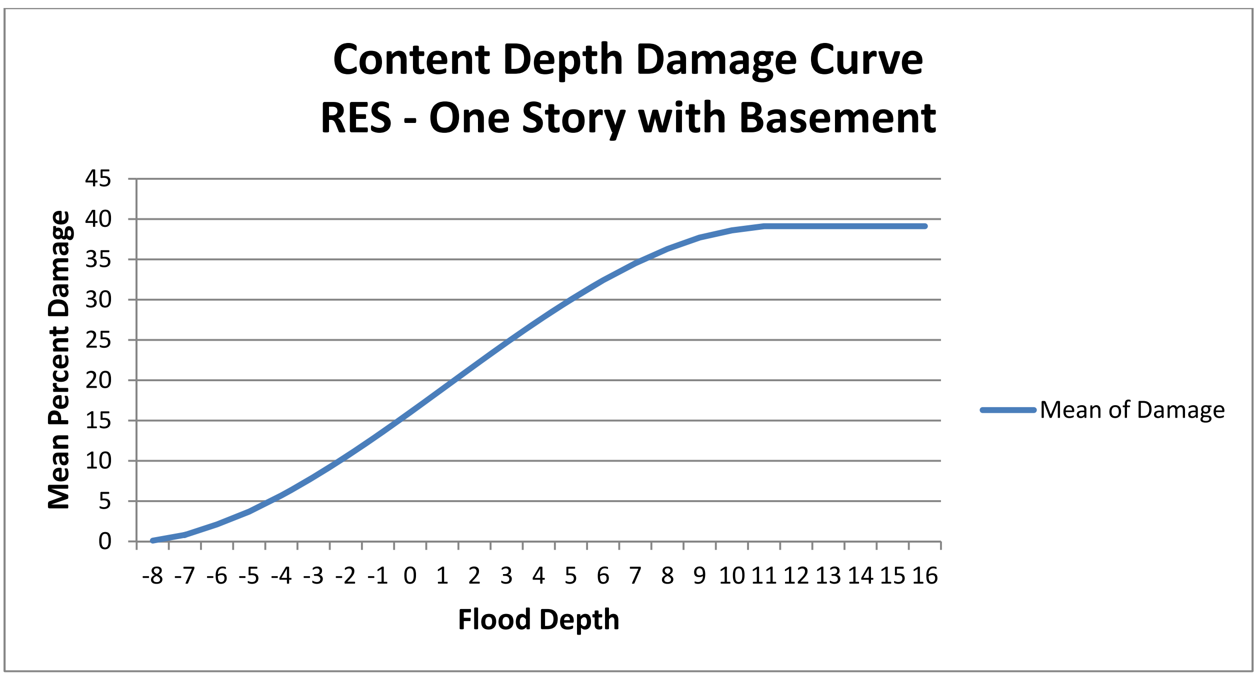


Figure 2-10: Content Depth-Damage Curve – Residential, One-Story, With Basement

2.3.2 Automobiles

The residential structure inventory in each study area was used to determine the location of automobiles. Two sources provided estimates of the number of vehicles per household. The Department of Transportation (2009) estimated an average of 1.9 vehicles per household for the United States; American Factfinder (U.S. Census Bureau, 2014) estimated 1.8 vehicles per household for Hancock County, and 2.1 vehicles per household for Putnam County. Based on the findings, two vehicles per residential household were considered appropriate for use in the study. According to the Southeast Louisiana Evacuation Behavioral Report (2006) following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the vehicles are parked at residences and are subject to flooding. It was assumed that a similar evacuation pattern would be used for Findlay, with 30 percent of the automobiles remaining at the household when evacuating. The elevation of the automobiles was assumed to be the elevation of the structure's adjacent grade, which was estimated using digital elevation maps and GIS.

In the United States, the average value of used vehicles varies by age and location. News articles on values of used vehicle have ranged from $12,000 to $16,000, while the National Automobile Dealers Association (NADA) placed the average value of a used vehicle at approximately $15,700. The value of the automobiles that could be damaged was adjusted for use in HEC-FDA by multiplying the number of automobiles per household, the value of the automobiles, and the percent of automobiles remaining (2 x $15,700 x 30%). This figure was rounded to $10,000 per household for the calculation of damages. Damages were calculated for each automobile using DDFs developed by IWR. The automobile inventory and associated data were input into HEC-FDA to calculate the damages.

2.4 Expected Annual Damage Calculations

2.4.1 Terminology

Average Annual Damage (AAD) and Benefit (AAB)
When evaluating flood damages, it is useful to relate the amount of damage to the water surface elevation in the river. In turn, each water surface elevation is related to certain amount of flow, and each flow is related to a frequency probability of exceedance. Therefore, each level of damage can be associated with a frequency, resulting in a damage-frequency curve. Average annual damage (AAD) is defined as the area under the damage-frequency curve.

Typically, AAD does not incorporate uncertainty in flows, water surface elevations, or damages. However, the term is often confused with expected annual damages. For the purposes of this report, AAD will represent the deterministic area under the damage-frequency curve (with no uncertainty).

AAD represents the average amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The average value is based on the frequency of recurrence for each flood event. No other probabilistic variables are factored into the calculation of AAD.

AAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions.

The average annual benefit (AAB) for any alternative is the difference between AAD without the alternative in place and AAD with the alternative in place.

Expected Annual Damage (EAD) and Benefit (EAB)

Expected annual damage (EAD) takes into account uncertainties in stage-damage, stage-flow, and flow-frequency relationships. EAD is the mean value of AAD, given the uncertainty associated with each damage, stage, and flow relationship. AAD and EAD are often confused due to the similarity in the terms "average" and "expected." For the purposes of this report, expected annual damages refers to the probabilistic definition offered above. EAD is computed using HEC-FDA version 1.2.4, which utilizes the Monte Carlo method for evaluating mean values.

Expected annual damage represents the mean amount of damage that would occur in **any given year**, if **that year** were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage flow, and flow-frequency relationships.

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions.

Expect annual benefit (EAB) for any alternative is the difference between EAD without the alternative in place and EAD with the alternative in place.

Equivalent Expected Annual Damage (EEAD) and Benefit (EEAB)

Throughout the period of analysis, EAD can vary if there are changes in hydraulic, hydrologic, or economic conditions. If each year is taken in sequence from the beginning of the period of analysis to the end, the result is a series or "stream" of EAD values. Equivalent Expected Annual Damage (EEAD) is the equivalent annual value of the EAD stream. It is computed by amortizing the net present value of the EAD stream. Equivalent values are not necessarily probabilistic values, and depend only on the discount rate, the number of years in the period of analysis, and the stream of values. The only uncertainties accounted for in EEAD are those already accounted for in EAD.

EEAD values do not vary by year and serve as a means of comparing benefits and costs in a consistent manner. Equivalent expected annual benefit (EEAB) for any alternative is the difference between EEAD without the alternative in place and EEAD with the alternative in place. The EEAB represents the benefit that the alternative yields each year. Based on time value of money, the EEAB value is "equivalent" to the benefit stream yielded by the project. From an investment perspective, someone earning an annuity equal to the EEAB value for the life of the project would be no better and no worse off if he or she earned the benefit stream instead.

2.4.2 HEC-FDA Analysis

The HEC-FDA program provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans. The program follows functional elements of a study involving coordinated study layout and configuration, hydrologic engineering analyses, economic analyses, and plan formulation and evaluation. You use it continuously throughout the planning process as the study evolves from the base year without-project condition analysis through the analyses of alternative plans over their project life. Hydrologic engineering and economics (flood inundation damage analysis) are performed separately, in a coordinated manner after specifying the study configuration and layout and merged for the formulation and evaluation of potential flood risk management plans.

The USACE requires the use of risk analysis procedures for formulating and evaluating flood risk management measures (EM 110-2-1619, ER 1105-2-101). These documents describe how to quantify uncertainty in discharge-exceedance probability, stage-discharge, and stage-damage functions, and incorporate it into economic and engineering performance analyses of alternatives. The process applied Monte Carlo simulation, a numerical-analysis procedure that computes the expected value of damage, while explicitly accounting for the uncertainty in the basic parameters used to determine flood inundation damage. HEC has developed the FDA computer program to assist in analysis flood risk management plans using these procedures.

Appropriate data for residential and nonresidential structures and automobiles were incorporated into HEC-FDA, Version 1.2.4. HEC-FDA uses modeled flooding events to estimate damages to affected structures based on data associated with each structure. HEC-FDA was used to estimate the damages for structures, contents, and automobiles. The HEC-FDA program compiles data generated during the H&H analyses, as well as the structure inventory and associated data described above. The H&H components used in this analysis included the water surface profiles for every stream for each of the eight analyzed exceedance probability flood events: 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year) and 0.2% (500-year) flood events.

These compiled data are a series of probabilistic curves defining relationships between flood stage and frequency of occurrence, and flood stage and damages. These relationships are used to generate a curve relating probability of occurrence and total damages; the integration of which provides the EAD.

With-project and without-project damages are estimated for both the initial baseline conditions and future conditions, which account for any growth in development and runoff in the study area. As the hydrologic condition of the study area is not anticipated to increase over the period of analysis, the HEC-FDA model was run only for the initial baseline condition, with the resulting annual damages expected to prevail over the 50-year period of analysis.

2.4.3 HEC-FDA Uncertainty

The USACE requires the use of risk-based analysis to evaluate flood damages and flood damage reduction measures, as described in ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*. HEC-FDA uses a Monte Carlo simulation to quantify uncertainty (risk) and derive EADs. This random sampling approach computes successive iterations of each computation for which there is uncertainty, using the assigned standard deviations of error and averages the results.

Various measures of uncertainty can be incorporated into the HEC-FDA models. For this study, uncertainty was incorporated into the results of the H&H analysis, the DDF curves, and the FFE of structures.

Uncertainty in H&H. Uncertainty associated with the H&H analysis was incorporated into the flow exceedance probability in the equivalent record lengths and the stage discharge functions. H&H Appendix A further discusses the uncertainty associated with the exceedance probability functions and the stage discharge functions.

Uncertainty in DDFs. The values associated with the DDFs are not known with certainty. The IWR and Galveston District curves include uncertainty in the damage to structure and contents. The uncertainty was defined through a triangular probability distribution for each unique DDF. Where interviews were conducted, uncertainty was only applied to the structure component. Where the EGM DDFs were used, uncertainty was applied to both the structure and content components.

Uncertainty in FFEs. Because the FFE was based on the surveyor's field estimate and the adjacent grade was based on approximations using digital elevation maps, a reasonable margin of error was likely to be present. To determine the margin of error, a quality assurance/quality control exercise was performed on the collected data. Professional surveyors determined the FFE for 30 randomly selected structures. The surveyors measured the FFE and adjacent grade to +/− 0.1 foot. The data gathered from this random sample was used to perform a comparative analysis, using the previously collected data for each structure as the base. The three categories analyzed were:

- Difference in total FFE
- Difference between the recorded first-floor adjustments
- Difference between the adjacent grade elevations used

A statistical analysis was performed on the error values under each of these categories. Table 2-5 shows the results of the statistical analyses for the city of Findlay.

Table 2-5: FFE Quality Assurance / Quality Control Analysis

Statistic	FFE Difference
Average	0.04
Max	2.03
Min	-1.79
Std. dev.	**1.02**

A standard deviation of 1.0 was incorporated into the HEC-FDA model runs to account for uncertainty in the FFE for the Findlay study area.

2.5 Ancillary Benefit Categories

Ancillary benefits have been captured beyond the scope of HEC-FDA inundation reduction benefits. Specifically, emergency response costs avoided, reoccupation costs avoided, evacuation and subsistence costs avoided and NFIP administrative costs avoided.

These benefits categories are classified as non-physical emergency costs; therefore they are valid from the NED perspective.

The following USACE guidance defines non-physical flood losses and emergency costs:

ER 1105-2-100 - Section 3-3 Flood Damage Reduction - Types of Flood Damage:

Non-physical flood losses: Nonphysical flood losses include income losses and emergency costs. Income losses are the loss of wages or net profits to business over and above physical flood damages that usually result from a disruption of normal activities. Estimates of these losses must be derived from specific independent economic data for the interests and properties affected. Prevention of income losses result in a contribution to national economic development only to the extent that the losses cannot be compensated for by postponement of an activity or transfer of the activity to other establishments. Emergency costs include those expenses resulting from a flood that would not otherwise be incurred. For example, the costs of evacuation and reoccupation, flood fighting, and administrative costs of disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research and should not be estimated by applying arbitrary percentages to the physical damage estimates.

Economic and Environmental P&G -Section IV—NED Benefit Evaluation Procedures: Urban Flood Damage - 2.4.2:

Emergency costs: Emergency costs include those expenses resulting from a flood that would not otherwise be incurred, such as the costs of evacuation and reoccupation, flood fighting, and disaster relief; increased cost of normal operations during the flood and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research and should not be estimated by applying arbitrary percentages to the physical damage estimates.

2.5.1 Emergency Response Costs Avoided

Emergency response costs are incurred by Federal, State, and local government agencies to provide emergency services and debris removal during a flood.

Emergency response estimates were provided for residential ($1,900) and non-residential ($11,200) structures by Steve Wilson, Hancock County, OH Engineer. All estimates were provided in March 2015 prices.

The following process was employed to estimate emergency response costs avoided:

1. HEC-FDA Structure_Detail.out tables were used to calculate the number of residential and non-residential structures experiencing inundation for all alternatives and the following array of flood events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2%.

2. Residential and non-residential tallies were multiplied by the average emergency cost per residential and non-residential structure ($11,200 and $1,900, respectively), for each flood event.

3. With project emergency response costs were subtracted from without project costs to estimate benefits for each flood event.

4. Benefits were annualized by estimating the area under the damage-frequency curve.

Emergency response calculations are displayed in section 5.0.

A risk and uncertainty analysis was not performed on emergency response costs avoided since they are a small component of overall benefits.

2.5.2 Evacuation and Subsistence Costs Avoided

Large floods may necessitate the evacuation of residences and the subsequent payment of government subsistence to residents who are required to seek alternative shelter. Reduction in flooding would reduce or eliminate these costs.

Evacuation and subsistence expenditures per evacuated household were estimated based on Federal government per diem for lodging and subsistence in the study area for fiscal year 2015. The standard daily rate for hotels is $83 and the daily standard rate for meals is $46 per person. The net cost of meals per person was estimated as $35.80 after subtracting the average daily cost of meals prepared at home for a male age 19-50 (USDA - $10.20).

The average household size in Findlay, OH is 2.28 people (U.S. Census Bureau, American Community Survey 2012).The total daily evacuation and subsistence cost for an average household in Findlay is $165. According to data provided by Steve Wilson, Hancock County, OH engineer, s, the average inundated household spent 10.5 days away from home during a flood event. Thus, the average evacuation and subsistence cost per household is $1,730 in Findlay.

The following process was employed to estimate evacuation and subsistence costs avoided:

1. HEC-FDA Structure_Detail.out tables were used to calculate the number of residential structures experiencing inundation for all alternatives and the following array of flood events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2%.

2. Residential tallies were multiplied by the average evacuation and subsistence cost per household ($1,730), for each flood event.

3. With project emergency response costs were subtracted from without project costs to estimate benefits for each flood event.

4. Benefits were annualized by estimating the area under the damage-frequency curve.

Evacuation and subsistence calculations are displayed in section 5.0.

A risk and uncertainty analysis was not performed on evacuation and subsistence costs avoided since they are a small component of overall benefits.

2.5.3 Reoccupation Costs Avoided

Flooding events may cause homeowners to incur reoccupation costs. These reoccupation costs include costs to contract, supervise, and inspect repairs and to clean and disinfect homes. A reduction in flooding would reduce or eliminate these costs.

Reoccupation cost estimates were provided by Steve Wilson, Hancock County, OH Engineer. The average cost of repairing a residential structure was estimated to be $5,000 (March 2015 prices), and the hourly burden per household for clean-up and repairs totaled 350 hours.

Since homeowners are forgoing other activities, including work and leisure, an opportunity cost of time was included in the analysis. Opportunity cost of work ($20.72) was estimated by dividing Findlay's 2012 median household income ($43,101) by yearly work hours (2,080). Opportunity cost of leisure was estimated at 2/3 of wage ($13.81). Post flood, owners were assumed to forego work one-third of the time, and recreation two-thirds of the time, which yields a $16.12 average value of time (($20.72*.333) + ($13.81*.666)). The average clean-up and repairs household burden totals $5,640 ($16.12 average value of time * 350 hours).

The cost of repairing a residential structure ($5,000) was added to the opportunity cost of time to clean and repair a residential structure ($5,640) to obtain the total reoccupation cost per residential structure ($10,640).

The following process was employed to estimate reoccupation costs avoided:

1. HEC-FDA Structure_Detail.out tables were used to calculate the number of residential structures experiencing inundation for all alternatives and the following array of flood events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2%.

2. Residential tallies were multiplied by the average reoccupation cost per household ($10,640), for each flood event.

3. With project emergency response costs were subtracted from without project costs to estimate benefits for each flood event.

4. Benefits were annualized by estimating the area under the damage-frequency curve.

Reoccupation calculations are displayed in section 5.0.

A risk and uncertainty analysis was not performed on reoccupation costs avoided since they are a small component of overall benefits.

2.5.4 National Flood Insurance Program (NFIP) Administrative Costs Avoided

Homes and buildings in high-risk flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance.

When an insured home is flooded administrative costs are incurred to service claims. A reduction in flooding would reduce or eliminate these claims and associated costs. Reduced administrative costs are a claimable flood risk management benefit per USACE EGM 06-04.

The following process was employed to estimate NFIP administrative costs avoided:

1. HEC-FDA Structure_Detail.out tables were used to calculate the number of residential structures experiencing inundation for all alternatives and the following array of flood events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2%.

2. Residential tallies were multiplied by the average NFIP administrative cost per household ($192), for each flood event.

3. With project emergency response costs were subtracted from without project costs to estimate benefits for each flood event.

4. Benefits were annualized by estimating the area under the damage-frequency curve.

NFIP administrative cost calculations are displayed in section 5.0.

A risk and uncertainty analysis was not performed on NFIP administrative costs avoided since they are a small component of overall benefits.

2.5.5 Transportation Costs Avoided

Transportation costs avoided have not been quantified to date, but will be included in the economic analysis prior to release of the Final Detailed Project Report. The following paragraphs summarize the proposed method to estimate transportation costs avoided.

A flood event can have significant impacts on a transportation network. These impacts include road closures, and impediment of traffic flow between origin and destination resulting in increased travel times due to detours.

The first step in transportation cost estimation involves analyzing the current transportation infrastructure and obtaining automobile use rates. Average daily traffic counts will be obtained from the Ohio Department of Transportation (ODOT) to assist with this analysis.

H&H water surface profiles and associated flood durations will be used to determine affected roads by flood event (50% 20%, 10%, 4%, 2%, 1%, 0.005% and 0.002%) for every alternative. This analysis will be cross referenced with ODOT average daily traffic counts to determine the number of vehicles that would be affected. GIS will also used to determine distance (miles) and time (hours) required to circumvent the flooded area to capture the costs associated with detours.

Variable vehicle operating cost increases will be estimated by multiplying increased mileage by federal variable vehicle operating cost rates.

Opportunity cost of time increases will be estimated by multiplying detoured vehicle counts by the average vehicle occupancy rate to estimate the number of persons affected by the detour. This estimate will be multiplied by the additional time associated with the detour (assuming vehicle travel at speed limits) to obtain total burdened hours. Burdened hours will be multiplied by the average wage for Hancock County to capture the opportunity cost of time for detoured travelers.

The final stage of this analysis involves constructing a frequency-damage curve from the results of these simulations. From this curve, annual damages to transportation will be estimated.

2.5.6 Agricultural Damages Avoided

Agricultural damages avoided have not been quantified to date, but will be included in the economic analysis prior to release of the Final Detailed Project Report. The following paragraphs summarize the proposed method to estimate transportation costs avoided.

Ponding and flooding can damage crops, but the extent of the damage depends on the type of plant, growth stage, air temperature, and the duration of the flooding. In general:

- Plants with some growth above the water level are more likely to survive.
- A warmer mid-summer flood increases the rate of damage and death to submerged plants, whereas plants can survive longer under water during a colder spring flood.

- Plants that encounter flash-flooding, where the water rises and recedes quickly, are more likely to survive than longer-duration flooding.

The agricultural analysis will focus on Hancock County, where the primary crops grown are soybeans, corn, and wheat.

Soybeans can generally survive for 2 to 4 days when completely submersed. The actual time frame depends on air temperature, cloud cover, soil moisture conditions prior to flooding, and rate of soil drainage. Cool air temperatures and cloudy days increase the survival of a flooded soybean crop; whereas in temperatures of 80 degrees Fahrenheit or above, soybean plants may only survive a few days. Increased soil moisture conditions prior to flooding and a decreased rate of soil drainage contribute to the buildup of toxins and carbon dioxide, which is more damaging to plants than lack of oxygen.

The extent to which ponding and flooding damages corn crops is determined by the plant stage of development when ponding occurs, the duration of ponding, and the air temperature. Prior to the 6-leaf collar stage or when the growing plant is at or below the soil surface, corn can usually survive only 2 to 4 days of flooded conditions. If the air temperature is greater than 77 degrees Fahrenheit during ponding, corn plants may not survive 24 hours, but cooler air temperatures (mid-60s or cooler) can prolong survival up to about 4 days. Also, once the growing point is above the water level, the likelihood for survival improves greatly.

The most significant factor affecting wheat during a flooding event is air temperature. During summer conditions, plant growth can be impacted after 2 to 3 days of flooding. If the air temperature is above 65 degrees Fahrenheit and the plants are submerged for more than 5 to 7 days, the wheat crops will not survive. There is limited information on the effect of flooding on wheat when temperatures are below 40 degrees Fahrenheit. Under cooler temperatures, the negative effects of flooding take longer to impact plant tissues, so winter wheat can tolerate flooding beyond the limits described above for summer conditions.

The methodology applied to evaluate flood damages to crops is described in the Economic and Watershed Technical Notes 16 (“Economics – Basic Data for Evaluating Floodwater Damages to Crops and Pastures in the Northeast,” NRCS, 1978) and 28 (“Economics – A Manual Procedure to Estimate Annual Crop and Pasture Flood Damages,” NRCS, 1972). The following basic data were used in the agricultural damages estimation:

- The land use, average crop production (bushels per acre), and crop progress and condition by month in Hancock and Putnam Counties was obtained from the U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS).

- Costs of farm operation per acre (crop production costs) were obtained from the Ohio State University Farm Management 2012 Enterprise Budgets.

- The USDA Economic Research Service provided the 2012 normalized value of production per acre by county and crop (based on 5-year lagged averages of actual market prices).

- Air temperature ranges and probabilities by month were obtained from Weather Spark.

- Crop floodwater damage percentages indicate the average loss of yield by month compared to flood-free conditions. The percentages vary according to the depth and the duration of the flood event and were vetted by the Hancock County Soil and Water Conservation District.

- The number of acres flooded for the with- and without-project conditions were estimated by month for varying magnitudes of flooding for the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent-chance flood events.

The method for calculating agricultural benefits will begin with the identification of land use and cropping patterns. The study will focus on the three primary crops grown in the study area: soybeans, corn, and wheat. The crop distribution is assumed to remain consistent over the period of analysis for each alternative that is being considered. The analysis used the following crop distribution for Hancock County:

- 46 percent soybeans
- 36 percent corn
- 18 percent wheat

H&H modeling in conjunction with GIS will provide the number of acres flooded less than one day, 1 to 2 days, 2 to 3 days, and more than 3 days for each flood recurrence interval. Then the acres were identified as soybean, corn or wheat crops according the crop distribution. The damages will be valued by analyzing the production function of farm land under the with- and without-project alternatives. Assuming the cropping pattern will not change; the benefit will be determined by using the applicable farm budget and the likelihood of a yield loss and/or need for replanting according to each month of the year.

The reduction in crop yield as a result of flooding will be estimated from publications and work on other studies (Butzen, 2010; Elmore and Abendroth, 2008; Nielsen, 2011; Pedersen, 2008; Ransom, 2009; Thomison, 2012), but primarily from the USDA Natural Resources Conservation Service study, *Final Supplementation Watershed Plan No. 1 and Environmental Assessment for Big Slough Watershed.* Table 2-6 presents the anticipated reduction in yield, which accounts for the impacts of air temperature, crop progress by month, and whether there is an opportunity to replant the crop. Flooding durations less than the amount described above would have minimal impacts on the yield.

Table 2-6: Potential Reduction in Yield from Flooding

	Soybeans	Winter Wheat	Corn
January	No loss	100% yield loss	No loss
February	No loss	100% yield loss	No loss
March	No loss	100% yield loss	No loss
April	Replanting	100% yield loss	Replanting
May	Replanting	100% yield loss	Replanting & 25% yield loss
June	Replanting & 25% yield loss	10–65% yield loss	50–75% yield loss
July	50–100% yield loss	0% loss	100% yield loss
August	100% yield loss	0% loss	100% yield loss
September	65–100% yield loss	Replanting	60–85% yield loss
October	10–65% yield loss	Replanting	25–50% yield loss
November	0–5% yield loss	25% yield loss	10–30% yield loss
December	No loss	40–100% yield loss	No loss

Replanting costs, based on the Ohio State University Farm Management Enterprise Budgets, were estimated to be:

- $132 per acre for soybeans
- $258 per acre for corn
- $148 per acre for wheat

Using the value of production per acre and the average yield for each crop, the normalized value of production per bushel was calculated (Table 2-7).

Table 2-7: Normalized Value of Production

	Wheat Yield	Wheat Value per Acre	Wheat Value per Bushel	Corn Yield	Corn Value per Acre	Corn Value per Bushel	Soybean Yield	Soybean Value per Acre	Soybean Value per Bushel
Hancock County	64.8	$287.62	$4.44	150.9	$519.16	$3.44	44.6	$376.70	$8.45
Putnam County	61.5	$273.15	$4.44	149.9	$515.79	$3.44	43.2	$365.04	$8.45
Average	**63.2**	**$280.39**	**$4.44**	**150.4**	**$517.48**	**$3.44**	**43.9**	**$370.87**	**$8.45**

The full damages (complete loss of crop) for each month will be calculated by multiplying the average value of the crop per acre (Table 2-7) and adding the replanting cost if necessary by the percentage yield loss (Table 2-6).It is assumed that damages would occur under two scenarios, if there was 2 to 3 days of flooding or more than 3 days of flooding. To estimate the damages for each of these scenarios and each flood event, the full damages for each month will be multiplied by the corresponding probability that each flood event would occur in that particular month. The probability that a flood event would occur in a particular month will be obtained by observing the maximum peak yearly stream flow data for the USGS gage nearest Findlay for the period of 1923 to 2011.There were 85 events, with the majority occurring during the winter and spring (nearly 79 percent). The damages for each scenario will be multiplied by the corresponding number of acres damaged for each crop and for each flood event. The NED benefit is the net increase in yield attributable to a with-project alternative.

3.0 Alternative Formulation

3.1 Structural Measures

Structural measures reduce flood risk by modifying the characteristics of the flood. They are often employed to reduce peak flows (flood storage), direct floodwaters away from damageable property (flood barriers), or facilitate the flow of water through or around an area (channel modifications or diversions).

Structural flood risk management alternatives were developed for the Findlay area by combining screened measures. Each alternative was evaluated against criteria developed at the in-progress review charette conducted in July 2012 and contained in the Decision Management Plan prepared in August 2012.

3.2 Non-Structural Measures

Non-structural measures reduce flood risk by modifying the characteristics of the buildings and structures that are subject to floods, or modifying the behavior of people living in or near floodplains. In general, non-structural alternatives do not modify the characteristics of floods nor do they induce development in a floodplain that is inconsistent with reducing flood risk. A screening of nonstructural alternatives was undertaken to determine whether they could be implemented as a part of a cost-shared project component.

In order to assign and evaluate nonstructural measures, a Statistical Analysis System (SAS) based algorithm was utilized. This algorithm assigns least cost non-structural measures based on various flood depths and adjusts structure attributes given the selected measure. For example, if a three-foot structural raise is assigned it would amend first floor elevation three feet higher than the original value. Revised structure attributes were used to estimate expected annual benefits via HEC-FDA.

The nonstructural algorithm was developed by USACE New York District, See Attachment B – Non-Structural Flow Chart for additional info.

The measures included in the non-structural analysis are: (1) dry floodproofing, (2) wet floodproofing, (3) elevation, (4) acquisition or buyout, (5) floodwalls for individual buildings, and (6) rebuilding. These measures are discussed in detail in the following section.

3.2.1 Dry Floodproofing

This nonstructural technique consists of waterproofing the structure. This can be done to residential homes as well as commercial and industrial structures. This measure achieves flood risk reduction, but it is not recognized by the NFIP for any flood insurance premium rate reduction if applied to a residential structure. Based on laboratory tests, a "conventional" built structure can generally only be dry flood proofed up to 3-feet in elevation. A structural analysis of the wall strength would be required if it was desired to achieve higher protection. A sump-pump and perhaps a French drain system should be installed as part of the measure. Closure panels are used at openings; this does not work with basements nor does it work with crawl spaces. For buildings with basements and/or crawlspaces, the only way that dry floodproofing could be considered to work is for the first floor to be made impermeable to the passage of floodwater.

3.2.2 Wet Floodproofing

This nonstructural technique is applicable as either a stand-alone measure or as a measure combined with other measures, such as elevation. As a stand-alone measure, all construction materials and finishing materials need to be water resistant and all utilities must be elevated above the design flood elevation. Wet floodproofing is quite applicable to commercial and industrial structures when combined with a flood warning and flood preparedness plan. This measure is generally not applicable to large flood depths and high velocity flows.

3.2.3 Elevation

This nonstructural technique lifts an existing structure to an elevation which is at least equal to or greater than the 1% annual chance flood elevation. In many elevation scenarios, the cost of elevating a structure an extra foot or two is less expensive than the first foot due to the cost incurred for mobilizing equipment. Elevation can be performed using fill material on extended foundation walls, on piers, post, piles and columns. Elevation is also a very successful technique for slab on grade structures.

3.2.4 Acquisition and Buyout

This nonstructural technique consists of buying the structure and the land. The structure is either demolished or is sold to others and relocated to a site external to the floodplain. Development sites, if needed, can be part of a proposed project in order to provide locations where displaced people can build new homes within an established community.

3.2.5 Floodwalls

This nonstructural technique is applicable on a small-scale basis. As nonstructural measures, floodwalls should be constructed to no higher than 6 feet above grade and should not be considered for certification through the NFIP, meaning that flood insurance and floodplain management requirements of the NFIP are still applicable in areas were these floodwalls are constructed. These nonstructural measures are intended to reduce the frequency of flooding, but not eliminate floodplain management and flood insurance requirements. These measures can be placed around a single structure or a small group of structures. Since applications of these measures are considered nonstructural in nature, they cannot raise the water surface elevation of the 100-year flood by any more than 0.00 feet.

3.2.6 Rebuilding

Rebuilding refers to demolishing a flood-prone structure and replacing it with a new structure built to comply with local regulations regarding new construction and substantial improvements in a floodplain, and therefore, is at a lower risk. This is not technically a retrofit; however, the result is a similar structure located within the same floodplain, elevated to comply with floodplain management regulations. The rebuild option is typically considered only where the costs were found to be less than those associated with other retrofitting measures

4.0 Alternatives Defined

The without-project alternative, four structural alternatives, and three combined structural and nonstructural alternatives were evaluated for this analysis. This section presents the economic evaluation of the Findlay alternatives. See the Main Report and accompanying appendices for additional details related to the development of this alternative array.

4.1 Alternative #1

Without Project Condition or No Action Plan:

This alternative reflects the current, or baseline condition. The purpose of including the no action alternative is to provide a consistent baseline for comparison against other alternatives, and to describe the flood impacts associated with not developing a flood risk management project. Consideration of the No Action Plan is required by USACE guidance.

4.2 Alternative #2

2% Annual Chance (50-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee:

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. For Alternative 2, the diversion channel is designed for the 2% annual chance (50-year) event. That is, the diversion channel is designed to handle the 2% annual chance (50-year) flow for Eagle Creek upstream of the diversion point, minus the 50% annual chance (2-year) flow, which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix A.

4.3 Alternative #3

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. The diversion channel is designed for the 1% annual chance (100-year) event. That is, the diversion channel is designed to handle the 1% annual chance (100-year) flow for Eagle Creek upstream of the diversion point, minus the 50% annual chance (2-year) flow, which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix A.

4.4 Alternative #4

0.4% Annual Chance (250-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee:

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. The diversion channel is designed for the 0.4% annual chance (250-year) event. That is, the diversion channel is designed to handle the 0.4% annual chance (250-year) flow for Eagle Creek upstream of the diversion point, minus the 50% annual chance (2-year), flow which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix A.

4.5 Alternative #5

1% Annual Chance (100-Year) Event Diversion Channel without Blanchard-Lye Cutoff Levee:

Alternative 3 without the Blanchard-Lye Cutoff Levee.

4.6 Alternative #6

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 5-Year Non-Structural:

Alternative 3 with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 5-year flood. The list of non-structural measures by structure count is displayed in Table 4-1.

Table 4-1: Alternative 6 - Non-Structural Measures

MEASURE	STRUCTURE COUNT
Buyout	12
Raise AC + louvers	7
Raise	3
Rebuild	1
Total:	23

4.7 Alternative #7

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 10-Year Non-Structural:

Same as Alternative 2, with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 10-year flood. The list of non-structural measures by structure count is displayed in Table 4-2.

Table 4-2: Alternative 7 - Non-Structural Measures

MEASURE	STRUCTURE COUNT
Buyout	13
Raise AC + louvers	7
Raise	5
Rebuild	2
Total:	27

4.8 Alternative #8

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 25-Year Nonstructural

Same as Alternative 2, with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 25-year flood. The list of non-structural measures by structure count is displayed in Table 4-3.

Table 4-3: Alternative 8 – Non-Structural Measures

MEASURE	STRUCTURE COUNT
Raise	24
Buyout	18
Raise AC + louvers	12
Ringwall	7
Seal & close	4
Rebuild	4
Fill_base + util_rm	3
Wet + util_room	1
Total:	73

4.9 Alternative #9

Blanchard-Lye Cutoff Levee Only

This alternative consists of a levee that is built to separate headwater from Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix (Appendix A).

5.0 National Economic Development (NED) Analysis

In flood risk management studies, benefits typically represent the reduction in damages associated with the without-project alternative. Therefore, benefits are calculated as the difference between the without-project damages and with-project damages. The benefits of each alternative were based on reduction in damages to: structure, contents, and automobiles; emergency response; evacuation and subsistence; reoccupation; agriculture; and, transportation.

The costs associated with implementing each alternative incorporate all of the costs associated with the design, construction, and administration of the flood-risk-management features. The costs were based on November 2014 prices and a project life of 50 years, and were annualized to an average annual cost using the FY15 Federal Discount Rate of 3.375 percent. Refer to Cost Engineering Appendix F for a detailed review of the costs associated with each alternative.

5.1 Alternative 1

Without Project Condition or No Action Plan:

5.1.1 Description

This alternative reflects the current, or baseline condition. The purpose of including the no action alternative is to provide a consistent baseline for comparison against other alternatives, and to describe the flood impacts associated with not developing a flood risk management project.

5.1.2 Benefit Analysis

Structure, Contents, and Automobile Damages

The processes for computing damages for structure, content, and automobiles are described in Section 2.3. Table 5-1 displays the number of structures inundated for the without project condition, by exceedance probability, Table 5-2 presents without project condition expected annual damages, by reach, and Table 5-3 presents without project condition expected annual damages by reach and structure category.

Table 5-1 displays structures that flood at or above FFE. Although instances of basement flooding are not included in this table, they are incorporated into the overall benefit calculation.

Table 5-1: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-2: Alternative 1 - Without Project Condition Damages by Reach ($000)

Alernative 1 - Without Project Condition			
Stream Name/Reach ID	Stream Name/ Reach ID	Without-Project EAD	
Blanchard River			
	FB1	$	0.22
	FB2	$	54.34
	FB3	$	367.40
	FB4L	$	37.82
	FB4R	$	31.50
	FB5L	$	233.71
	FB5R	$	290.15
	FB6L	$	508.38
	FB6R	$	416.75
	FB7	$	330.77
	FB8	$	331.04
	FB9L	$	41.28
	FB9R	$	1.15
	FB10L	$	1.43
	FB10R	$	25.35
	FB11	$	6.91
	Subtotal:	$	2,678.21
Eagle Creek	Eagle Creek		
	EC1L	$	159.21
	EC1R	$	141.85
	EC2L	$	88.71
	EC2R	$	91.18
	EC3L	$	128.52
	EC3R	$	584.24
	EC4aL	$	15.38
	EC4aR	$	192.60
	EC4bL	$	15.36
	EC4bR	$	-
	EC5	$	-
Lye Creek	*Subtotal:*	$	1,417.04
	Lye Creek		
	LC1	$	83.80
	LC2	$	768.24
	LC3	$	25.55
	Subtotal:	$	877.59
	GRAND TOTAL:	**$**	**4,972.84**

Table 5-3: Alternative 1 – Without Project Condition Average Annual Damages by Structure Category ($000)

Stream Name	Reach	Expected Annual Damages					
		AUTO	COM	IND	P&O	RES	Total
Blanchard River							
	FB1	$ -	$ 0.22	$ -	$ -	$ -	$ 0.22
	FB2	$ -	$ 54.34	$ -	$ -	$ -	$ 54.34
	FB3	$ -	$ 101.14	$ -	$ 266.26	$ -	$ 367.40
	FB4L	$ 0.32	$ 34.04	$ -	$ 0.40	$ 3.07	$ 37.82
	FB4R	$ 2.14	$ 3.46	$ -	$ 0.60	$ 25.31	$ 31.50
	FB5L	$ 20.91	$ 34.95	$ -	$ 1.92	$ 175.94	$ 233.71
	FB5R	$ 12.55	$ 49.03	$ -	$ 41.11	$ 187.47	$ 290.15
	FB6L	$ 2.78	$ 445.48	$ 0.02	$ 33.05	$ 27.04	$ 508.38
	FB6R	$ 18.25	$ 205.88	$ -	$ 107.79	$ 84.84	$ 416.75
	FB7	$ 29.41	$ 128.60	$ 0.00	$ 17.73	$ 155.03	$ 330.77
	FB8	$ 18.00	$ 88.70	$ -	$ 0.33	$ 224.01	$ 331.04
	FB9L	$ 1.47	$ 0.85	$ 0.59	$ 1.24	$ 37.13	$ 41.28
	FB9R	$ 0.03	$ -	$ -	$ -	$ 1.13	$ 1.15
	FB10L	$ 0.18	$ 0.02	$ -	$ -	$ 1.22	$ 1.43
	FB10R	$ 0.94	$ 1.18	$ -	$ 0.00	$ 23.23	$ 25.35
	FB11	$ 0.47	$ 2.12	$ -	$ -	$ 4.33	$ 6.91
	Subtotal	$ 107.44	$ 1,149.99	$ 0.61	$ 470.43	$ 949.73	$ 2,678.21
Eagle Creek							
	EC1L	$ 4.78	$ 88.53	$ 0.06	$ 9.89	$ 55.95	$ 159.21
	EC1R	$ 4.90	$ 94.59	$ 0.62	$ 0.25	$ 41.49	$ 141.85
	EC2L	$ 7.72	$ 1.06	$ -	$ -	$ 79.93	$ 88.71
	EC2R	$ 6.94	$ 18.60	$ -	$ 1.74	$ 63.88	$ 91.18
	EC3L	$ 7.71	$ 0.02	$ -	$ -	$ 120.79	$ 128.52
	EC3R	$ 48.15	$ 0.00	$ -	$ -	$ 536.09	$ 584.24
	EC4aL	$ 0.92	$ 0.37	$ -	$ 4.23	$ 9.85	$ 15.38
	EC4aR	$ 6.51	$ -	$ -	$ -	$ 186.09	$ 192.60
	EC4bL	$ 0.72	$ 5.59	$ -	$ -	$ 9.05	$ 15.36
	EC4bR	$ -	$ -	$ -	$ -	$ -	$ -
	EC5	$ -	$ -	$ -	$ -	$ -	$ -
	Subtotal	$ 88.36	$ 208.77	$ 0.68	$ 16.12	$ 1,103.11	$ 1,417.04
Lye Creek							
	LC1	$ 12.08	$ 6.82	$ -	$ -	$ 64.89	$ 83.80
	LC2	$ 30.91	$ 78.01	$ -	$ 49.66	$ 609.66	$ 768.24
	LC3	$ 1.65	$ 0.17	$ -	$ 0.00	$ 23.73	$ 25.55
	Subtotal	$ 44.64	$ 85.00	$ -	$ 49.66	$ 698.28	$ 877.59
GRAND TOTAL:		**$ 240.44**	**$ 1,443.76**	**$ 1.29**	**$ 536.21**	**$ 2,751.12**	**$ 4,972.84**

Emergency Response

The processes for computing damages for emergency response are described in Section 2.4. Table 5-4 presents emergency response AADs for the without-project alternative.

Table 5-4: Alternative 1 - Emergency Response Average Annual Damages ($000)

Alternative	USD ($000)
Without Project - Average Annual Damage:	$167.2

Evacuation and Subsistence

The processes for computing damages for evacuation and subsistence are described in Section 2.5. Table 5-5 presents evacuation and subsistence AADs for the without-project alternatives.

Table 5-5: Alternative 1 - Evacuation and Subsistence Average Annual Damages ($000)

Alternative	USD ($000)
Without Project - Average Annual Damage:	$74.5

Reoccupation

The processes for computing damages for reoccupation are described in Section 2.6. Table 5-6 presents reoccupation AADs for the without-project alternatives.

Table 5-6: Alternative 1 – Reoccupation Average Annual Damages ($000)

Alternative	USD ($000)
Without Project - Average Annual Damage:	$457.9

National Flood Insurance Program (NFIP) Administrative Costs

The processes for computing damages for reoccupation are described in Section 2.6. Table 5-7 presents reoccupation AADs for the without-project alternatives.

Table 5-7: Alternative 1 – NFIP Average Annual Administrative Costs ($000)

Alternative	USD ($000)
Without Project - Average Annual Damage:	$8.3

5.2 Alternative 2

2% Annual Chance (50-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee:

5.2.1 Description

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. For Alternative 2, the diversion channel is designed for the 2% annual chance (50-year) event. That is, the diversion channel is designed to handle the 2% annual chance (50-year) flow for Eagle Creek upstream of the diversion point, minus the 50% annual chance (2-year) flow which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix A.

5.2.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-8 displays the number of structures inundated under the without project condition by exceedance probability.

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-9 displays the number of structures being protected with alternative 2 by exceedance probability. Table 5-10 displays the number of structures that continue to be inundated (residual structures) with alternative 2, by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-8: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-9: Alternative 2 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	22	32	83	90	63
IND:	-	-	-	-	1	1	-	-
P&O:	-	-	-	3	4	11	14	10
RES:	-	15	59	121	305	894	1,120	752
TOTAL:	-	15	65	146	342	989	1,224	825

Table 5-10: Alternative 2 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	29	46	68	184	303
IND:	-	-	-	-	-	1	2	3

P&O:	-	-	-	1	4	6	23	41
RES:	5	7	15	48	81	204	770	1,663
TOTAL:	5	7	21	78	131	279	979	2,010

Table 5-11 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-11: Alternative 2 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #2 - Q=50 with BLCL			
Stream Name/Reach ID	Without-Project EAD	Alternative #2 - Expected Annual Benefits	Alternative #2 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.10	$ 0.12
FB2	$ 54.34	$ 28.13	$ 26.21
FB3	$ 367.40	$ 178.59	$ 188.81
FB4L	$ 37.82	$ 23.07	$ 14.75
FB4R	$ 31.50	$ 15.30	$ 16.20
FB5L	$ 233.71	$ 126.71	$ 107.00
FB5R	$ 290.15	$ 134.08	$ 156.07
FB6L	$ 508.38	$ 225.81	$ 282.57
FB6R	$ 416.75	$ 174.15	$ 242.60
FB7	$ 330.77	$ 124.37	$ 206.40
FB8	$ 331.04	$ 200.60	$ 130.44
FB9L	$ 41.28	$ 19.03	$ 22.25
FB9R	$ 1.15	$ 0.35	$ 0.80
FB10L	$ 1.43	$ (0.23)	$ 1.65
FB10R	$ 25.35	$ (14.20)	$ 39.56
FB11	$ 6.91	$ (4.38)	$ 11.30
Subtotal:	$ 2,678.21	$ 1,231.47	$ 1,446.74
Eagle Creek			
EC1L	$ 159.21	$ 154.13	$ 5.08
EC1R	$ 141.85	$ 136.00	$ 5.85
EC2L	$ 88.71	$ 84.75	$ 3.96
EC2R	$ 91.18	$ 85.18	$ 6.00
EC3L	$ 128.52	$ 113.21	$ 15.30
EC3R	$ 584.24	$ 453.98	$ 130.26
EC4aL	$ 15.38	$ 13.11	$ 2.26
EC4aR	$ 192.60	$ 157.95	$ 34.65
EC4bL	$ 15.36	$ 14.92	$ 0.43
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,213.24	$ 203.80
Lye Creek			
LC1	$ 83.80	$ 40.97	$ 42.83
LC2	$ 768.24	$ 631.87	$ 136.37
LC3	$ 25.55	$ 12.83	$ 12.72
Subtotal:	$ 877.59	$ 685.66	$ 191.93
GRAND TOTAL:	**$ 4,972.84**	**$ 3,130.37**	**$ 1,842.46**

Emergency Response

Table 5-12 displays emergency response average annual benefits and average annual residual damages for alternative 2.

Table 5-12: Alternative 2 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 2 - Average Annual Residual Damage:	$74.5
Alternative 2 - Average Annual Benefit:	$92.7

Evacuation and Subsistence

Table 5-13 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 2.

Table 5-13: Alternative 2 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 2 - Average Annual Residual Damage:	$22.2
Alternative 2 - Average Annual Benefit:	$52.3

Reoccupation

Table 5-14 presents reoccupation average annual benefits and average annual residual damages for alternative 2.

Table 5-14: Alternative 2 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 2 - Average Annual Residual Damage:	$144.6
Alternative 2 - Average Annual Benefit:	$313.3

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-15 presents NFIP average annual benefits and average annual residual damages for alternative 2.

Table 5-15: Alternative 2 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 2 - Average Annual Residual Damage:	$8.3
Alternative 2 - Average Annual Benefit:	$0

5.2.3 Economic Evaluation

Table 5-16 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 2. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-16: Alternative 2 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Q = 50 Diversion Channel with Blanchard-Lye Cutoff

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 3,130,400
Emergency Response Costs Avoided:	$ 92,700
Reoccupation Costs Avoided:	$ 313,300
Evacuation and Subsistence Costs Avoided:	$ 52,300
NFIP Administrative Costs Avoided:	$ -
Total AA Benefits:	$ 3,588,700

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS
$ 567,700

BC ANALYSIS		
AA BENEFIT:	$	3,588,700
AA COST:	$	3,021,000
BC Ratio:		1.19

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 66,335,000
Interest During Construction:	$ 2,975,000
Total Investment Costs:	$ 69,310,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 2,889,000
Average Annual O&M Cost:	$ 109,000
Average Annual Monitoring Cost:	$ 23,000
Total AA Costs:	$ 3,021,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 2,092,040

5.3 Alternative 3

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee

5.3.1 Description

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. The diversion channel is designed for the 1% annual chance (100-year) event. That is, the diversion channel is designed to handle the 1% annual chance (100-year) flow for Eagle

Creek upstream of the diversion point, minus the 50% annual chance (2-year) flow which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix (Appendix A).

5.3.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-17 displays the number of structures inundated under the without project condition by exceedance probability.

Table 5-18 displays the number of structures being protected with alternative 3 by exceedance probability. Table 5-19 displays the number of structures that continue to be inundated (residual structures) with alternative 3 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-17: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-18: Alternative 3 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	22	32	87	144	67
IND:	-	-	-	-	1	2	-	-
P&O:	-	-	-	3	4	12	23	10
RES:	-	15	59	121	305	951	1,320	843
TOTAL:	-	15	65	146	342	1,052	1,487	920

Table 5-19: Alternative 3 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	29	46	64	130	299
IND:	-	-	-	-	-	-	2	3
P&O:	-	-	-	1	4	5	14	41
RES:	5	7	15	48	81	147	570	1,572
TOTAL:	5	7	21	78	131	216	716	1,915

Table 5-20 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-20: Alternative 3 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #3 - Q=100 with BLCL			
Stream Name/Reach ID	Without-Project EAD	Alternative #3 - Expected Annual Benefits	Alternative #3 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.11	$ 0.10
FB2	$ 54.34	$ 31.27	$ 23.07
FB3	$ 367.40	$ 190.84	$ 176.56
FB4L	$ 37.82	$ 24.72	$ 13.10
FB4R	$ 31.50	$ 16.28	$ 15.22
FB5L	$ 233.71	$ 136.16	$ 97.55
FB5R	$ 290.15	$ 143.19	$ 146.97
FB6L	$ 508.38	$ 250.04	$ 258.33
FB6R	$ 416.75	$ 187.74	$ 229.01
FB7	$ 330.77	$ 140.83	$ 189.95
FB8	$ 331.04	$ 217.56	$ 113.48
FB9L	$ 41.28	$ 22.27	$ 19.00
FB9R	$ 1.15	$ 0.49	$ 0.66
FB10L	$ 1.43	$ (0.16)	$ 1.58
FB10R	$ 25.35	$ (11.22)	$ 36.58
FB11	$ 6.91	$ (4.38)	$ 11.29
Subtotal:	$ 2,678.21	$ 1,345.75	$ 1,332.46
Eagle Creek			
EC1L	$ 159.21	$ 158.06	$ 1.15
EC1R	$ 141.85	$ 140.45	$ 1.40
EC2L	$ 88.71	$ 86.44	$ 2.27
EC2R	$ 91.18	$ 87.65	$ 3.52
EC3L	$ 128.52	$ 116.46	$ 12.06
EC3R	$ 584.24	$ 465.60	$ 118.64
EC4aL	$ 15.38	$ 13.54	$ 1.83
EC4aR	$ 192.60	$ 162.42	$ 30.18
EC4bL	$ 15.36	$ 15.19	$ 0.17
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,245.82	$ 171.23
Lye Creek			
LC1	$ 83.80	$ 45.54	$ 38.26
LC2	$ 768.24	$ 641.85	$ 126.38
LC3	$ 25.55	$ 13.87	$ 11.68
Subtotal:	$ 877.59	$ 701.27	$ 176.32
GRAND TOTAL:	**$ 4,972.84**	**$ 3,292.84**	**$ 1,680.01**

Emergency Response

Table 5-21 displays emergency response average annual benefits and average annual residual damages for alternative 3.

Table 5-21: Alternative 3 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 3 - Average Annual Residual Damage:	$68.5
Alternative 3 - Average Annual Benefit:	$98.7

Evacuation and Subsistence

Table 5-22 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 3.

Table 5-22: Alternative 3 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 3 - Average Annual Residual Damage:	$21.2
Alternative 3 - Average Annual Benefit:	$53.3

Reoccupation

Table 5-23 presents reoccupation average annual benefits and average annual residual damages for alternative 3.

Table 5-23: Alternative 3 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 3 - Average Annual Residual Damage:	$130.1
Alternative 3 - Average Annual Benefit:	$327.8

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-24 presents NFIP average annual benefits and average annual residual damages for alternative 3.

Table 5-24: Alternative 3 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 3 - Average Annual Residual Damage:	$2.3
Alternative 3 - Average Annual Benefit:	$6.0

5.3.3 Economic Evaluation

Table 5-25 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 3. Refer Cost Engineering Appendix F for a detailed review of the costs.

Table 5-25: Alternative 3 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Q = 100 Diversion Channel with Blanchard-Lye Cutoff

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 3,292,800
Emergency Response Costs Avoided:	$ 98,700
Reoccupation Costs Avoided:	$ 327,800
Evacuation and Subsistence Costs Avoided:	$ 53,300
NFIP Administrative Costs Avoided:	$ 6,000
Total AA Benefits:	$ 3,778,600

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS
$ 671,600

BC ANALYSIS	
AA BENEFIT:	$ 3,778,600
AA COST:	$ 3,107,000
BC Ratio:	1.22

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 68,319,000
Interest During Construction:	$ 3,074,000
Total Investment Costs:	$ 71,393,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 2,975,000
Average Annual O&M Cost:	$ 109,000
Average Annual Monitoring Cost:	$ 23,000
Total AA Costs:	$ 3,107,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 1,902,140

5.4 Alternative 4

0.4% Annual Chance (250-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee:

5.4.1 Description

A diversion channel is built to divert high flows from Eagle Creek to the Blanchard River, downstream of Findlay. The diversion channel alignment extends from Eagle Creek upstream of Route 30 to the Blanchard River downstream of Aurand Run. A gated flow control structure on Eagle Creek restricts flow in Eagle Creek to a maximum of the 50% annual chance (2-year return period) flow. Flows in excess of the 50% annual chance flow are directed into the diversion channel. The diversion channel is designed for the 0.4% annual chance (250-year) event. That is, the diversion channel is designed to handle the 0.4% annual chance (250-year) flow for Eagle Creek upstream of the diversion point, minus the 50% annual chance (2-year) flow which is allowed to continue in Eagle Creek, downstream of the diversion point.

Additionally, a levee is built to separate headwater Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of H&H Appendix A.

5.4.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-26 displays the number of structures inundated under the without project condition by exceedance probability. Table 5-27 displays the number of structures being protected with alternative 4 by exceedance probability. Table 5-28 displays the number of structures that continue to be inundated (residual structures) with alternative 4 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-26: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-27: Alternative 4 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	22	32	87	167	72
IND:	-	-	-	-	1	2	-	-
P&O:	-	-	-	3	4	12	24	12
RES:	-	15	59	121	305	951	1,472	910
TOTAL:	-	15	65	146	342	1,052	1,663	994

Table 5-28: Alternative 4 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	29	46	64	107	294
IND:	-	-	-	-	-	-	2	3
P&O:	-	-	-	1	4	5	13	39
RES:	5	7	15	48	81	147	418	1,505
TOTAL:	5	7	21	78	131	216	540	1,841

Table 5-29 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-29: Alternative 4 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #4 - Q=250 with BLCL			
Stream Name/Reach ID	Without-Project EAD	Alternative #4 - Expected Annual Benefits	Alternative #4 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.12	$ 0.10
FB2	$ 54.34	$ 32.64	$ 21.70
FB3	$ 367.40	$ 195.72	$ 171.68
FB4L	$ 37.82	$ 25.52	$ 12.30
FB4R	$ 31.50	$ 16.75	$ 14.75
FB5L	$ 233.71	$ 139.83	$ 93.88
FB5R	$ 290.15	$ 146.70	$ 143.45
FB6L	$ 508.38	$ 256.95	$ 251.43
FB6R	$ 416.75	$ 190.97	$ 225.78
FB7	$ 330.77	$ 146.59	$ 184.19
FB8	$ 331.04	$ 224.41	$ 106.62
FB9L	$ 41.28	$ 23.50	$ 17.78
FB9R	$ 1.15	$ 0.56	$ 0.60
FB10L	$ 1.43	$ (0.13)	$ 1.56
FB10R	$ 25.35	$ (8.66)	$ 34.01
FB11	$ 6.91	$ (4.39)	$ 11.30
Subtotal:	$ 2,678.21	$ 1,387.08	$ 1,291.12
Eagle Creek			
EC1L	$ 159.21	$ 159.09	$ 0.12
EC1R	$ 141.85	$ 141.69	$ 0.16
EC2L	$ 88.71	$ 86.86	$ 1.85
EC2R	$ 91.18	$ 88.39	$ 2.78
EC3L	$ 128.52	$ 116.90	$ 11.62
EC3R	$ 584.24	$ 478.69	$ 105.55
EC4aL	$ 15.38	$ 13.80	$ 1.58
EC4aR	$ 192.60	$ 164.32	$ 28.28
EC4bL	$ 15.36	$ 15.27	$ 0.08
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,265.01	$ 152.03
Lye Creek			
LC1	$ 83.80	$ 47.36	$ 36.44
LC2	$ 768.24	$ 645.58	$ 122.65
LC3	$ 25.55	$ 13.93	$ 11.62
Subtotal:	$ 877.59	$ 706.88	$ 170.71
GRAND TOTAL:	**$ 4,972.84**	**$ 3,358.97**	**$ 1,613.86**

Emergency Response

Table 5-30 displays emergency response average annual benefits and average annual residual damages for alternative 4.

Table 5-30: Alternative 4 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 4 - Average Annual Residual Damage:	$66.0
Alternative 4 - Average Annual Benefit:	$101.2

Evacuation and Subsistence

Table 5-31 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 4.

Table 5-31: Alternative 4 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 4 - Average Annual Residual Damage:	$19.9
Alternative 4 - Average Annual Benefit:	$54.6

Reoccupation

Table 5-32 presents reoccupation average annual benefits and average annual residual damages for alternative 4.

Table 5-32: Alternative 4 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 4 - Average Annual Residual Damage:	$122.5
Alternative 4 - Average Annual Benefit:	$335.4

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-33 presents NFIP average annual benefits and average annual residual damages for alternative 4.

Table 5-33: Alternative 4 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 4 - Average Annual Residual Damage:	$2.2
Alternative 4 - Average Annual Benefit:	$6.1

5.4.3 Economic Evaluation

Table 5-34 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 4. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-34: Alternative 4 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Q = 250 Diversion Channel with Blanchard-Lye Cutoff

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 3,359,000
Emergency Response Costs Avoided:	$ 101,200
Reoccupation Costs Avoided:	$ 335,400
Evacuation and Subsistence Costs Avoided:	$ 54,600
NFIP Administrative Costs Avoided:	$ 6,100
Total AA Benefits:	$ 3,856,300

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS
$ 555,300

BC ANALYSIS	
AA BENEFIT:	$ 3,856,300
AA COST:	$ 3,301,000
BC Ratio:	**1.17**

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 72,746,000
Interest During Construction:	$ 3,295,000
Total Investment Costs:	$ 76,041,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 3,169,000
Average Annual O&M Cost:	$ 109,000
Average Annual Monitoring Cost:	$ 23,000
Total AA Costs:	$ 3,301,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 1,824,440

5.5 Alternative 5

1% Annual Chance (100-Year) Event Diversion Channel without Blanchard-Lye Cutoff Levee:

5.5.1 Description

This alternative is the same as alternative 3, excluding the Blanchard-Lye Cutoff Levee.

5.5.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-35 displays the number of structures inundated under the without project condition by exceedance probability. Table 5-36 displays the number of structures being protected with alternative 5 by exceedance probability. Table 5-37 displays the number of structures that continue to be inundated (residual structures) with alternative 5 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-35: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-36: Alternative 5 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	9	32	38	91	163	110
IND:	-	-	-	-	1	2	-	1
P&O:	-	-	-	4	5	12	24	18
RES:	-	15	61	130	260	721	1,073	686
TOTAL:	-	15	70	166	304	826	1,260	815

Table 5-37: Alternative 5 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	3	19	40	60	111	256
IND:	-	-	-	-	-	-	2	2
P&O:	-	-	-	-	3	5	13	33
RES:	5	7	13	39	126	377	817	1,729
TOTAL:	5	7	16	58	169	442	943	2,020

Table 5-38 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-38: Alternative 5 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #5 - Q=100 without BLCL			
Stream Name/Reach ID	Without-Project EAD	Alternative #5 - Expected Annual Benefits	Alternative #5 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.17	$ 0.05
FB2	$ 54.34	$ 41.50	$ 12.84
FB3	$ 367.40	$ 223.46	$ 143.94
FB4L	$ 37.82	$ 26.41	$ 11.41
FB4R	$ 31.50	$ 18.28	$ 13.22
FB5L	$ 233.71	$ 161.11	$ 72.60
FB5R	$ 290.15	$ 176.98	$ 113.18
FB6L	$ 508.38	$ 321.99	$ 186.38
FB6R	$ 416.75	$ 245.99	$ 170.76
FB7	$ 330.77	$ 184.28	$ 146.49
FB8	$ 331.04	$ 166.32	$ 164.71
FB9L	$ 41.28	$ 22.90	$ 18.38
FB9R	$ 1.15	$ 0.71	$ 0.44
FB10L	$ 1.43	$ 0.46	$ 0.97
FB10R	$ 25.35	$ 10.70	$ 14.65
FB11	$ 6.91	$ (0.04)	$ 6.96
Subtotal:	$ 2,678.21	$ 1,601.22	$ 1,076.99
Eagle Creek			
EC1L	$ 159.21	$ 158.12	$ 1.09
EC1R	$ 141.85	$ 140.49	$ 1.36
EC2L	$ 88.71	$ 86.24	$ 2.47
EC2R	$ 91.18	$ 87.64	$ 3.53
EC3L	$ 128.52	$ 117.23	$ 11.29
EC3R	$ 584.24	$ 464.68	$ 119.56
EC4aL	$ 15.38	$ 13.55	$ 1.83
EC4aR	$ 192.60	$ 162.81	$ 29.79
EC4bL	$ 15.36	$ 15.19	$ 0.17
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,245.95	$ 171.09
Lye Creek			
LC1	$ 83.80	$ 36.03	$ 47.77
LC2	$ 768.24	$ 25.84	$ 742.40
LC3	$ 25.55	$ (0.11)	$ 25.66
Subtotal:	$ 877.59	$ 61.76	$ 815.83
GRAND TOTAL:	**$ 4,972.84**	**$ 2,908.93**	**$ 2,063.91**

Emergency Response

Table 5-39 displays emergency response average annual benefits and average annual residual damages for alternative 5.

Table 5-39: Alternative 5 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 5 - Average Annual Residual Damage:	$63.5
Alternative 5 - Average Annual Benefit:	$103.7

Evacuation and Subsistence

Table 5-40 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 5.

Table 5-40: Alternative 5 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 5 - Average Annual Residual Damage:	$26.5
Alternative 5 - Average Annual Benefit:	$48.0

Reoccupation

Table 5-41 presents reoccupation average annual benefits and average annual residual damages for alternative 5.

Table 5-41: Alternative 5 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 5 - Average Annual Residual Damage:	$163.1
Alternative 5 - Average Annual Benefit:	$294.8

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-42 presents NFIP average annual benefits and average annual residual damages for alternative 5.

Table 5-42: Alternative 5 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 5 - Average Annual Residual Damage:	$2.9
Alternative 5 - Average Annual Benefit:	$5.4

5.5.3 Economic Evaluation

Table 5-43 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 5. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-43: Alternative 5 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Q = 100 Diversion Channel WITHOUT Blanchard-Lye Cutoff

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 2,908,900
Emergency Response Costs Avoided:	$ 103,700
Reoccupation Costs Avoided:	$ 294,800
Evacuation and Subsistence Costs Avoided:	$ 48,000
NFIP Administrative Costs Avoided:	$ 5,400
Total AA Benefits:	$ 3,360,800

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS
$ 601,800

BC ANALYSIS	
AA BENEFIT:	$ 3,360,800
AA COST:	$ 2,759,000
BC Ratio:	1.22

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 60,340,000
Interest During Construction:	$ 3,019,000
Total Investment Costs:	$ 63,359,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 2,641,000
Average Annual O&M Cost:	$ 95,000
Average Annual Monitoring Cost:	$ 23,000
Total AA Costs:	$ 2,759,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 2,475,640

5.6 Alternative 6

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 5-Year Non-Structural:

5.6.1 Description

Alternative 3 with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 5-year flood.

5.6.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-44 displays the number of structures inundated under the without project condition by exceedance probability. Table 5-45 displays the number of structures being protected with alternative 6 by exceedance probability. Table 5-46 displays the number of structures that continue to be inundated (residual structures) with alternative 6 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-44: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-45: Alternative 6 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	22	32	87	144	67
IND:	-	-	-	-	1	2	-	-
P&O:	-	-	-	3	4	12	23	10
RES:	5	22	59	121	305	951	1,320	843
TOTAL:	5	22	65	146	342	1,052	1,487	920

Table 5-46: Alternative 6 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	6	29	46	64	130	299
IND:	-	-	-	-	-	-	2	3
P&O:	-	-	-	1	4	5	14	41
RES:	-	-	15	48	81	147	570	1,572
TOTAL:	-	-	21	78	131	216	716	1,915

Table 5-47 represents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-47: Alternative 6 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #6 - Q=100, BLCL, NS-5			
Stream Name/Reach ID	Without-Project EAD	Alternative #6 - Expected Annual Benefits	Alternative #6 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.11	$ 0.10
FB2	$ 54.34	$ 31.27	$ 23.07
FB3	$ 367.40	$ 190.84	$ 176.56
FB4L	$ 37.82	$ 24.72	$ 13.10
FB4R	$ 31.50	$ 20.84	$ 10.66
FB5L	$ 233.71	$ 141.27	$ 92.44
FB5R	$ 290.15	$ 150.98	$ 139.18
FB6L	$ 508.38	$ 250.04	$ 258.33
FB6R	$ 416.75	$ 187.74	$ 229.01
FB7	$ 330.77	$ 141.08	$ 189.70
FB8	$ 331.04	$ 217.56	$ 113.48
FB9L	$ 41.28	$ 22.27	$ 19.00
FB9R	$ 1.15	$ 0.49	$ 0.66
FB10L	$ 1.43	$ (0.16)	$ 1.58
FB10R	$ 25.35	$ (11.22)	$ 36.58
FB11	$ 6.91	$ (4.38)	$ 11.29
Subtotal:	$ 2,678.21	$ 1,363.45	$ 1,314.76
Eagle Creek			
EC1L	$ 159.21	$ 158.06	$ 1.15
EC1R	$ 141.85	$ 140.45	$ 1.40
EC2L	$ 88.71	$ 86.44	$ 2.27
EC2R	$ 91.18	$ 87.65	$ 3.52
EC3L	$ 128.52	$ 116.46	$ 12.06
EC3R	$ 584.24	$ 477.75	$ 106.49
EC4aL	$ 15.38	$ 13.54	$ 1.83
EC4aR	$ 192.60	$ 162.42	$ 30.18
EC4bL	$ 15.36	$ 15.19	$ 0.17
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,257.97	$ 159.07
Lye Creek			
LC1	$ 83.80	$ 45.54	$ 38.26
LC2	$ 768.24	$ 641.85	$ 126.38
LC3	$ 25.55	$ 13.87	$ 11.68
Subtotal:	$ 877.59	$ 701.26	$ 176.32
GRAND TOTAL:	**$ 4,972.84**	**$ 3,322.68**	**$ 1,650.15**

Emergency Response

Table 5-48 displays emergency response average annual benefits and average annual residual damages for alternative 6.

Table 5-48: Alternative 6 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 6 - Average Annual Residual Damage:	$64.4
Alternative 6 - Average Annual Benefit:	$102.8

Evacuation and Subsistence

Table 5-49 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 6.

Table 5-49: Alternative 6 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 6 - Average Annual Residual Damage:	$17.4
Alternative 6 - Average Annual Benefit:	$57.1

Reoccupation

Table 5-50 presents reoccupation average annual benefits and average annual residual damages for alternative 6.

Table 5-50: Alternative 6 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 6 - Average Annual Residual Damage:	$107.2
Alternative 6 - Average Annual Benefit:	$350.7

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-51 presents NFIP average annual benefits and average annual residual damages for alternative 6.

Table 5-51: Alternative 6 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 6 - Average Annual Residual Damage:	$1.9
Alternative 6 - Average Annual Benefit:	$6.4

5.6.3 Economic Evaluation

Table 5-52 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 6. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-52: Alternative 6 – Economic Evaluation

ECONOMIC PARAMETERS		
FY15 Federal Discount Rate:		3.375%
Partial Payment Factor:		0.041677
Present Worth $1 (50 Years @ 3.375%):	$	23.99

Q = 100 Diversion Channel, Blanchard-Lye Cutoff, 5-Year Non-Structural

BENEFITS

AVERAGE ANNUAL BENEFITS		
Residential, Commercial, Auto Damages Avoided:	$	3,292,800
Non-Structural Residential and Commercial Damages Avoided:	$	29,900
Emergency Response Costs Avoided:	$	102,800
Reoccupation Costs Avoided:	$	350,700
Evacuation and Subsistence Costs Avoided:	$	57,100
NFIP Administrative Costs Avoided:	$	6,400
Total AA Benefits:	$	3,839,700

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS	
$	**497,700**

BC ANALYSIS		
AA BENEFIT:	$	3,839,700
AA COST:	$	3,342,000
BC Ratio:		**1.15**

COSTS

INVESTMENT COSTS		
Total First Cost:	$	73,934,000
Interest During Construction:	$	3,090,000
Total Investment Costs:	$	77,024,000

AVERAGE ANNUAL COSTS		
Average Annual Investment Cost:	$	3,210,000
Average Annual O&M Cost:	$	109,000
Average Annual Monitoring Cost:	$	23,000
Total AA Costs:	$	3,342,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	1,841,040

5.7 Alternative 7

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 10-Year Non-Structural:

5.7.1 Description

Same as Alternative 2, with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 10-year flood.

5.7.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-53 displays the number of structures inundated under the without project condition by exceedance probability.
Table 5-54 displays the number of structures being protected with alternative 7 by exceedance probability. Table 5-55 displays the number of structures that continue to be inundated (residual structures) with alternative 7 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-53: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-54: Alternative 7 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	22	32	87	144	67
IND:	-	-	-	-	1	2	-	-
P&O:	-	-	-	3	4	12	23	10
RES:	5	22	74	121	305	951	1,320	843
TOTAL:	5	22	86	146	342	1,052	1,487	920

Table 5-55: Alternative 7 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	-	29	46	64	130	299
IND:	-	-	-	-	-	-	2	3
P&O:	-	-	-	1	4	5	14	41
RES:	-	-	-	48	81	147	570	1,572
TOTAL:	-	-	-	78	131	216	716	1,915

Table 5-56 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damage

Table 5-56: Alternative 7 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #7 - Q=100, BLCL, NS-10			
Stream Name/Reach ID	Without-Project EAD	Alternative #7 - Expected Annual Benefits	Alternative #7 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.11	$ 0.10
FB2	$ 54.34	$ 31.27	$ 23.07
FB3	$ 367.40	$ 190.84	$ 176.56
FB4L	$ 37.82	$ 24.72	$ 13.10
FB4R	$ 31.50	$ 20.84	$ 10.66
FB5L	$ 233.71	$ 146.28	$ 87.43
FB5R	$ 290.15	$ 153.27	$ 136.88
FB6L	$ 508.38	$ 272.38	$ 236.00
FB6R	$ 416.75	$ 210.81	$ 205.95
FB7	$ 330.77	$ 201.11	$ 129.66
FB8	$ 331.04	$ 217.56	$ 113.48
FB9L	$ 41.28	$ 22.27	$ 19.00
FB9R	$ 1.15	$ 0.49	$ 0.66
FB10L	$ 1.43	$ (0.16)	$ 1.58
FB10R	$ 25.35	$ (11.22)	$ 36.58
FB11	$ 6.91	$ (4.21)	$ 11.13
Subtotal:	$ 2,678.21	$ 1,476.36	$ 1,201.84
Eagle Creek			
EC1L	$ 159.21	$ 158.06	$ 1.15
EC1R	$ 141.85	$ 140.45	$ 1.40
EC2L	$ 88.71	$ 86.44	$ 2.27
EC2R	$ 91.18	$ 87.65	$ 3.52
EC3L	$ 128.52	$ 116.46	$ 12.06
EC3R	$ 584.24	$ 477.75	$ 106.49
EC4aL	$ 15.38	$ 13.54	$ 1.83
EC4aR	$ 192.60	$ 162.42	$ 30.18
EC4bL	$ 15.36	$ 15.19	$ 0.17
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,257.97	$ 159.07
Lye Creek			
LC1	$ 83.80	$ 45.54	$ 38.26
LC2	$ 768.24	$ 641.85	$ 126.38
LC3	$ 25.55	$ 13.87	$ 11.68
Subtotal:	$ 877.59	$ 701.26	$ 176.32
GRAND TOTAL:	**$ 4,972.84**	**$ 3,435.60**	**$ 1,537.24**

Emergency Response

Table 5-57 displays emergency response average annual benefits and average annual residual damages for alternative 7.

Table 5-57: Alternative 7 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 7 - Average Annual Residual Damage:	$56.8
Alternative 7 - Average Annual Benefit:	$110.4

Evacuation and Subsistence

Table 5-58 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 7.

Table 5-58: Alternative 7 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 7 - Average Annual Residual Damage:	$15.4
Alternative 7 - Average Annual Benefit:	$59.1

Reoccupation

Table 5-59 presents reoccupation average annual benefits and average annual residual damages for alternative 7.

Table 5-59: Alternative 7 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 7 - Average Annual Residual Damage:	$94.4
Alternative 7 - Average Annual Benefit:	$363.5

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-60 presents NFIP average annual benefits and average annual residual damages for alternative 7.

Table 5-60: Alternative 7 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 7 - Average Annual Residual Damage:	$1.7
Alternative 7 - Average Annual Benefit:	$6.6

5.7.3 Economic Evaluation

Table 5-61 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 7. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-61: Alternative 7 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Q = 100 Diversion Channel, Blanchard-Lye Cutoff, 10-Year Non-Structural

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 3,292,800
Non-Structural Residential and Commercial Damages Avoided:	$ 142,800
Emergency Response Costs Avoided:	$ 110,400
Reoccupation Costs Avoided:	$ 363,500
Evacuation and Subsistence Costs Avoided:	$ 59,100
NFIP Administrative Costs Avoided:	$ 6,600
Total AA Benefits:	$ 3,975,200

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS
$ 584,200

BC ANALYSIS	
AA BENEFIT:	$ 3,975,200
AA COST:	$ 3,391,000
BC Ratio:	1.17

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 75,101,000
Interest During Construction:	$ 3,093,000
Total Investment Costs:	$ 78,194,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 3,259,000
Average Annual O&M Cost:	$ 109,000
Average Annual Monitoring Cost:	$ 23,000
Total AA Costs:	$ 3,391,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES
$ 1,705,540

5.8 Alternative 8

1% Annual Chance (100-Year) Event Diversion Channel with Blanchard-Lye Cutoff Levee with 25-Year Nonstructural

5.8.1 Description

Same as Alternative 2, with least cost non-structural measures applied (per non-structural algorithm) to buildings inundated at the 25-year flood.

5.8.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-62 displays the number of structures inundated under the without project condition by exceedance probability. Table 5-63 displays the number of structures being protected with alternative 8 by exceedance probability. Table 5-64 displays the number of structures that continue to be inundated (residual structures) with alternative 8 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-62: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-63: Alternative 8 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	32	87	144	67
IND:	-	-	-	-	1	2	-	-
P&O:	-	-	-	4	4	12	23	10
RES:	5	22	74	169	305	951	1,320	843
TOTAL:	5	22	86	224	342	1,052	1,487	920

Table 5-64: Alternative 8 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	-	-	46	64	130	299
IND:	-	-	-	-	-	-	2	3
P&O:	-	-	-	-	4	5	14	41
RES:	-	-	-	-	81	147	570	1,572
TOTAL:	-	-	-	-	131	216	716	1,915

Table 5-65 presents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-65: Alternative 8 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #8 - Q=100, BLCL, NS-25			
Stream Name/Reach ID	Without-Project EAD	Alternative #8 - Expected Annual Benefits	Alternative #8 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ 0.11	$ 0.10
FB2	$ 54.34	$ 31.27	$ 23.07
FB3	$ 367.40	$ 190.84	$ 176.56
FB4L	$ 37.82	$ 24.72	$ 13.10
FB4R	$ 31.50	$ 20.84	$ 10.66
FB5L	$ 233.71	$ 154.25	$ 79.46
FB5R	$ 290.15	$ 195.23	$ 94.92
FB6L	$ 508.38	$ 325.26	$ 183.12
FB6R	$ 416.75	$ 264.52	$ 152.23
FB7	$ 330.77	$ 228.36	$ 102.41
FB8	$ 331.04	$ 221.67	$ 109.37
FB9L	$ 41.28	$ 22.27	$ 19.00
FB9R	$ 1.15	$ 0.49	$ 0.66
FB10L	$ 1.43	$ (0.16)	$ 1.58
FB10R	$ 25.35	$ (10.68)	$ 36.04
FB11	$ 6.91	$ 0.13	$ 6.79
Subtotal:	$ 2,678.21	$ 1,669.12	$ 1,009.08
Eagle Creek			
EC1L	$ 159.21	$ 158.06	$ 1.15
EC1R	$ 141.85	$ 141.10	$ 0.75
EC2L	$ 88.71	$ 86.44	$ 2.27
EC2R	$ 91.18	$ 88.59	$ 2.59
EC3L	$ 128.52	$ 116.46	$ 12.06
EC3R	$ 584.24	$ 477.75	$ 106.49
EC4aL	$ 15.38	$ 13.54	$ 1.83
EC4aR	$ 192.60	$ 162.42	$ 30.18
EC4bL	$ 15.36	$ 15.19	$ 0.17
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ 1,259.56	$ 157.48
Lye Creek			
LC1	$ 83.80	$ 46.19	$ 37.61
LC2	$ 768.24	$ 651.12	$ 117.12
LC3	$ 25.55	$ 13.87	$ 11.68
Subtotal:	$ 877.59	$ 711.18	$ 166.41
GRAND TOTAL:	**$ 4,972.84**	**$ 3,639.86**	**$ 1,332.98**

Emergency Response

Table 5-66 displays emergency response average annual benefits and average annual residual damages for alternative 8.

Table 5-66: Alternative 8 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 8 - Average Annual Residual Damage:	$13.2
Alternative 8 - Average Annual Benefit:	$154.0

Evacuation and Subsistence

Table 5-67 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 8.

Table 5-67: Alternative 8 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 8 - Average Annual Residual Damage:	$12.0
Alternative 8 - Average Annual Benefit:	$62.5

Reoccupation

Table 5-68 presents reoccupation average annual benefits and average annual residual damages for alternative 8.

Table 5-68: Alternative 8 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 8 - Average Annual Residual Damage:	$74.0
Alternative 8 - Average Annual Benefit:	$383.9

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-69 presents NFIP average annual benefits and average annual residual damages for alternative 8.

Table 5-69: Alternative 8 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 8 - Average Annual Residual Damage:	$1.3
Alternative 8 - Average Annual Benefit:	$7.0

5.8.3 Economic Evaluation

Table 5-70 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 8. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-70: Alternative 8 – Economic Evaluation

ECONOMIC PARAMETERS		
FY15 Federal Discount Rate:		3.375%
Partial Payment Factor:		0.041677
Present Worth $1 (50 Years @ 3.375%):	$	23.99

Q = 100 Diversion Channel, Blanchard-Lye Cutoff, 25-Year Non-Structural

BENEFITS

AVERAGE ANNUAL BENEFITS		
Residential, Commercial, Auto Damages Avoided:	$	3,292,800
Non-Structural Residential and Commercial Damages Avoided:	$	347,000
Emergency Response Costs Avoided:	$	154,000
Reoccupation Costs Avoided:	$	383,900
Evacuation and Subsistence Costs Avoided:	$	62,500
NFIP Administrative Costs Avoided:	$	7,000
Total AA Benefits:	$	4,247,200

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS	
$	276,200

BC ANALYSIS		
AA BENEFIT:	$	4,247,200
AA COST:	$	3,971,000
BC Ratio:		**1.07**

COSTS

INVESTMENT COSTS		
Total First Cost:	$	89,194,000
Interest During Construction:	$	3,132,000
Total Investment Costs:	$	92,326,000

AVERAGE ANNUAL COSTS		
Average Annual Investment Cost:	$	3,848,000
Average Annual O&M Cost:	$	109,000
Average Annual Monitoring Cost:	$	14,000
Total AA Costs:	$	3,971,000

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	1,433,540

5.9 **Alternative 9**

Blanchard-Lye Cutoff Levee Only

5.9.1 Description

This alternative consists of a levee that is built to separate headwater from Blanchard River, and Lye Creek flood flows. The levee alignment is consistent with the overflow weir location shown in Figure 29 of the H&H Appendix (Appendix A).

5.9.2 Benefit Analysis

Structure, Contents, and Automobile Damages

Table 5-71displays the number of structures inundated under the without project condition by exceedance probability. Table 5-72 displays the number of structures being protected with alternative 6 by exceedance probability. Table 5-73 displays the number of structures that continue to be inundated (residual structures) with alternative 6 by exceedance probability. These tables display structures that flood at or above FFE. Although instances of basement flooding are not included in these tables, they are incorporated into the overall benefit analysis.

Table 5-71: Without Project Condition – Inundated Structures by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	12	51	78	151	274	366
IND:	-	-	-	-	1	2	2	3
P&O:	-	-	-	4	8	17	37	51
RES:	5	22	74	169	386	1,098	1,890	2,415
TOTAL:	5	22	86	224	473	1,268	2,203	2,835

Table 5-72: Alternative 9 – Structures Protected by Exceedance Probability

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	0	0	-1	-2	-2	-4	-32	-6
IND:	0	0	0	0	0	0	-1	0
P&O:	0	0	0	0	-1	2	-5	-4
RES:	0	-1	4	-17	28	255	216	78
TOTAL:	0	-1	3	-19	25	253	178	68

Table 5-73: Alternative 9 – Inundated Structures by Exceedance Probability (Residual Structures)

Category	Annual Exceedance Probability							
	50%	20%	10%	4%	2%	1%	0.5%	0.2%
COM:	-	-	13	53	80	155	306	372
IND:	-	-	-	-	1	2	3	3
P&O:	-	-	-	4	9	15	42	55
RES:	5	23	70	186	358	843	1,674	2,337
TOTAL:	5	23	83	243	448	1,015	2,025	2,767

Table 5-74 represents without project condition expected annual damages, with project expected annual benefits and expected annual residual damages

Table 5-74: Alternative 9 – Structure, Content and Automobile Expected Annual Benefits and Residual Damages ($000)

Alternative #9 - Blanchard-Lye Cutoff Levee Only			
Stream Name/Reach ID	Without-Project EAD	Alternative #9 - Expected Annual Benefits	Alternative #9 - Expected Annual Residual Damages
Blanchard River			
FB1	$ 0.22	$ (0.11)	$ 0.33
FB2	$ 54.34	$ (19.16)	$ 73.50
FB3	$ 367.40	$ (30.40)	$ 397.80
FB4L	$ 37.82	$ (0.54)	$ 38.36
FB4R	$ 31.50	$ (1.44)	$ 32.94
FB5L	$ 233.71	$ (20.34)	$ 254.05
FB5R	$ 290.15	$ (31.53)	$ 321.68
FB6L	$ 508.38	$ (89.30)	$ 597.68
FB6R	$ 416.75	$ (51.76)	$ 468.51
FB7	$ 330.77	$ (41.11)	$ 371.89
FB8	$ 331.04	$ 81.52	$ 249.51
FB9L	$ 41.28	$ 0.66	$ 40.61
FB9R	$ 1.15	$ (0.45)	$ 1.60
FB10L	$ 1.43	$ (0.83)	$ 2.26
FB10R	$ 25.35	$ (30.68)	$ 56.03
FB11	$ 6.91	$ (4.40)	$ 11.32
Subtotal:	$ 2,678.21	$ (239.87)	$ 2,918.08
Eagle Creek			
EC1L	$ 159.21	$ (1.29)	$ 160.50
EC1R	$ 141.85	$ (0.51)	$ 142.36
EC2L	$ 88.71	$ 0.57	$ 88.15
EC2R	$ 91.18	$ (0.76)	$ 91.94
EC3L	$ 128.52	$ (0.70)	$ 129.22
EC3R	$ 584.24	$ 2.16	$ 582.09
EC4aL	$ 15.38	$ (0.06)	$ 15.43
EC4aR	$ 192.60	$ (0.12)	$ 192.72
EC4bL	$ 15.36	$ 0.03	$ 15.33
EC4bR	$ -	$ -	$ -
EC5	$ -	$ -	$ -
Subtotal:	$ 1,417.04	$ (0.70)	$ 1,417.74
Lye Creek			
LC1	$ 83.80	$ 6.25	$ 77.55
LC2	$ 768.24	$ 564.38	$ 203.85
LC3	$ 25.55	$ 12.49	$ 13.06
Subtotal:	$ 877.59	$ 583.12	$ 294.47
GRAND TOTAL:	**$ 4,972.84**	**$ 342.55**	**$ 4,630.29**

Emergency Response

Table 5-75 displays emergency response average annual benefits and average annual residual damages for alternative 6.

Table 5-75: Alternative 9 - Emergency Response Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$167.2
Alternative 6 - Average Annual Residual Damage:	$166.2
Alternative 6 - Average Annual Benefit:	$1.0

Evacuation and Subsistence

Table 5-76 presents evacuation and subsistence average annual benefits and average annual residual damages for alternative 6.

Table 5-76: Alternative 9 – Evacuation and Subsistence Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$74.5
Alternative 6 - Average Annual Residual Damage:	$69.7
Alternative 6 - Average Annual Benefit:	$4.8

Reoccupation

Table 5-77 presents reoccupation average annual benefits and average annual residual damages for alternative 6.

Table 5-77: Alternative 9 – Reoccupation Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$457.9
Alternative 6 - Average Annual Residual Damage:	$428.6
Alternative 6 - Average Annual Benefit:	$29.3

National Flood Insurance Program (NFIP) Administrative Costs

Table 5-78 presents NFIP average annual benefits and average annual residual damages for alternative 6.

Table 5-78: Alternative 9 - NFIP Average Annual Benefits and Residual Damages ($000)

Category	USD ($000)
Without Project - Average Annual Damage:	$8.3
Alternative 6 - Average Annual Residual Damage:	$7.7
Alternative 6 - Average Annual Benefit:	$0.6

5.9.3 Economic Evaluation

Table 5-79 summarizes benefits, costs, average annual net benefits and benefit cost ratios for alternative 6. Refer to Cost Engineering Appendix F for a detailed review of the costs.

Table 5-79: Alternative 9 – Economic Evaluation

ECONOMIC PARAMETERS	
FY15 Federal Discount Rate:	3.375%
Partial Payment Factor:	0.041677
Present Worth $1 (50 Years @ 3.375%):	$ 23.99

Blanchard-Lye Cutoff Levee Only

BENEFITS

AVERAGE ANNUAL BENEFITS	
Residential, Commercial, Auto Damages Avoided:	$ 342,600
Emergency Response Costs Avoided:	$ 1,000
Reoccupation Costs Avoided:	$ 29,300
Evacuation and Subsistence Costs Avoided:	$ 4,800
NFIP Administrative Costs Avoided:	$ 600
Total AA Benefits:	$ 378,300

COSTS

INVESTMENT COSTS	
Total First Cost:	$ 7,979,000
Interest During Construction:	$ 55,000
Total Investment Costs:	$ 8,034,000

AVERAGE ANNUAL COSTS	
Average Annual Investment Cost:	$ 335,000
Average Annual O&M Cost:	$ 14,000
Average Annual Monitoring Cost:	$ -
Total AA Costs:	$ 349,000

ECONOMIC ANALYSIS

FY15 Discount Rate = 3.375%

AVERAGE ANNUAL NET BENEFITS	
$	**29,300**

BC ANALYSIS	
AA BENEFIT:	$ 378,300
AA COST:	$ 349,000
BC Ratio:	**1.08**

RESIDUAL DAMAGES

AA RESIDUAL DAMAGES	
$	5,167,240

5.10 Summary of Findlay Alternatives

To identify cost-effective alternatives, as well as the alternative that maximizes NED benefits, alternatives were independently justified and compared against one another on the basis of monetized benefits. Alternatives were not considered economically justified or cost-effective unless their benefits exceed their costs. Alternatives justified in this manner were compared against one another on the basis of net benefits, which are the total monetized benefits of an alternative less its associated costs. Table 5-80 summarizes the result of the economic evaluation for the Findlay alternatives.

Table 5-80: Economic Evaluation of Findlay Alternatives ($000)

Alternative:	Annual Benefits:	Annual Costs:	Annual Net Benefits:	Benefit-Cost Ratio:
Alt #2 - Q50 Diversion + BLCL:	$ 3,588,300	$ 3,021,000	$ 567,300	1.19
Alt #3 - Q100 Diversion + BLCL:	**$ 3,778,800**	**$ 3,107,000**	**$ 671,800**	**1.22**
Alt #4 - Q250 Diversion + BLCL:	$ 3,856,300	$ 3,301,000	$ 555,300	1.17
Alt #5 - Q100 Diversion without BLCL:	$ 3,360,900	$ 2,759,000	$ 601,900	1.22
Alt #6 - Alt #3 & 5-Yr NS	$ 3,840,000	$ 3,342,000	$ 498,000	1.15
Alt #7 - Alt #3 & 10-Yr NS	$ 3,975,600	$ 3,391,000	$ 584,600	1.17
Alt #8 - Alt #3 & 25-Yr NS	$ 4,247,400	$ 3,971,000	$ 276,400	1.07
Alt #9 - Blanchard-Lye Cutoff Only	$ 382,700	$ 349,000	$ 33,700	1.10

Alternative #3 maximizes average annual net benefits; therefore, it is the NED Plan.

Sources:

Butzen, S. 2010. Flooding Impact on Crops. Pioneer Hi-Bred Int'l. Available online: http://www.pioneer.com/home/site/us/template.CONTENT/agronomy/crop-management/adverse-weather-disease/flood-damage/guid.DE1A9B1D-CAC0-4A04-B9CC-E0820B29080A

Elmore, R. and L. Abendroth. 2008. Flooded Corn and Saturated Soils. Integrated Crop Management Newsletter, Iowa State Univ Extension. Available online: http://www.extension.iastate.edu/CropNews/2008/0530RogerElmoreLori+Abendroth.htm

Nielsen, R.L. 2011. Effects of Flooding or Ponding on Young Corn. Corny News Network, Purdue University. Available online: http://www.kingcorn.org/news/timeless/PondingYoungCorn.html

Pedersen, P. 2008. Effect of flooding on emerged soybeans. Iowa State University Integrated Crop Management. Available online: http://www.extension.iastate.edu/CropNews/2008/0531PallePedersen2.htm; Nielsen, R.L.

Ransom, J. 2009. Flooding Impacts Winter Wheat. North Dakota State University Agricultural Communication. Available online: http://www.ag.ndsu.edu/news/newsreleases/2009/april-20-2009/flooding-impacts-winter-wheat/

Thomison, P. 2012. Ponding Effects on Corn and Soybeans. Ohio State University. Available online: http://agcrops.osu.edu/corn/newsletters/2012/corn-2012-13/ponding-effects-on-corn-and-soybean

United Stated Department of Agriculture, Natural Resources Conservation Service (NRCS). 2009. Final Supplementation Watershed Plan No. 1 and Environmental Assessment for Big Slough Watershed. Big Slough Watershed Improvement District, Clay County Conservation District, St. Francis Drainage District, City of Piggott, Arkansas

Attachment A - Commercial and Industrial Flood Damage Survey

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY FINDLAY, OHIO

(Personal Interview)

OMB Control Number: 0710-0001

The public report burden for this information collection is estimated to average 40 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this data collection, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Executive Services Directorate, Information Management Division, and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503, Attn.: Desk Officer for U.S. Army Corps of Engineers. Respondents should be aware that notwithstanding any other provision of law, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Please DO NOT RETURN your completed form to either of these offices.

*Be sure to notify each person to be interviewed that responding to questions is voluntary.

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY OMB#: 0710-0001

PRIMARY SURVEY FORM

Attach Business Card Here

Firm Name: __

This survey is focused on damages that could occur to the contents of structures at your facility in the event of future flooding. Contents are defined as items that would be relocated in the event that the facility moves to another location, such as furniture, equipment, products, and raw materials. For this survey contents were divided in three categories:

- **Equipment**: Physical items that are used for the production process or the operation of the facility (e.g., generators, machinery, production tables, paint booths, robotics, racks, conveyors, floor scrubbers, computers/servers, etc.). These items would most likely be removed if the business relocates to another facility.
- **Furniture**: Physical items necessary for the conduct of business or delivery of a product (e.g., desks, chairs, bookcases, artwork, etc.). As with equipment, this category is focused on free-standing and attached furniture that would be removed in the event of relocation.
- **Inventory/Products**: Items that are used in the production process or result from the production process, or consumables used as part of the business activities. Items include raw materials, finished products, replacement parts, medical consumables, cleaning products, food, pharmaceuticals, software, building materials, office supplies, etc.

Business Information

Address______

Contact Name

Contact's Title ____________________________________ Telephone # ____________________

Interviewer_________________________________ Date_____________ Time ______________

1. Type of business ____

2. Total number of buildings on site _____

3. Number of years business has been at this location _____

Flood History and Mitigation

4. Has your facility been flooded in the past? Yes No

If "Yes," please complete Questions 5 and 6. If "No," skip to Question 7.

5. Please estimate the damages to your business from past flooding events. Please give a single set of combined damages for all floors in all buildings.

Date of the flooding event:		Date of the flooding event:	
Water depth above first floor:		Water depth above first floor:	
Contents damage estimate ($):		Contents damage estimate ($):	
Structure damage estimate ($):		Structure damage estimate ($):	
Number of lost business days:		Number of lost business days:	
Amount of lost net income ($):		Amount of lost net income ($):	
Cost of cleanup ($):		Cost of cleanup ($):	

6. Briefly describe any permanent flood mitigation measures that have been implemented to reduce potential flood damage. __

___
___
___
___

Building Information

(Questions 7-17 are to be answered for your ***primary building only****. If there are multiple buildings at the facility, a supplemental sheet is provided that asks for similar information.)*

7. Building #: ___________

8. Brief description of function of the building and its contents: ___________________________

___
___
___

9. Year building was constructed: ________

10. Building Construction Type (e.g. brick): __________________

11. Number of floors (including basement, if any): _____________

12. Building footprint: __________ feet by __________ feet = ____________square feet

13. Does the building have a basement? Yes No If yes: _______ square feet finished area

_______ square feet unfinished area

14. Relative to the 1st floor elevation of the building, what is the cumulative current value of the contents and where are they located vertically? (up through 1st floor only)

Height (ft)	Equipment ($)	Furniture ($)	Inventory/products ($)
0.0 ft			
1.0 ft			
3.0 ft			
6.0 ft			
Total			

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Susceptibility to Flood Damage

The amount of damage due to flooding can vary considerably depending on conditions (e.g., quality of water, duration of flood). When completing the following section, you will be asked to provide a range for potential damages. In addition to the most likely damage amount due to flooding, you will also be asked to provide a low and high estimate. Please use the following definitions:

- *"Most Likely" – reasonable amount of damage expected to occur during an average flood.*
- *"Low" – reasonable low estimate of damages assuming that the flood conditions are less than a typical flood (e.g., short duration, relatively clean floodwaters) or the contents were less impacted than typically estimated (e.g., motors were sealed well).*
- *"High" – reasonable high estimate of damages assuming that the flood conditions are worse than a typical flood (e.g., long duration, highly contaminated floodwaters) or the contents were more impacted than typically estimated (e.g., motors need total replacement).*

15. At what elevation, relative to the 1st floor of the building, does flood damage to **contents** begin? (+ or – ; will only be negative if there is a subterranean level) ____________ feet

16. Please estimate damage to contents corresponding with water depths above/below the building's 1st floor elevation. (Express damage in either **$ or % of total value**.) Please consider your estimates of the total value of contents below each specified elevation (from Q 14 above) in formulating your damage estimates.

Flood Depth	Equipment			Furniture			Inventory/products		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
0.0 ft									
1.0 ft									
3.0 ft									
6.0 ft									

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Other Information

17. Other than the principal structures, are there any other valuable items on your property that flood waters could damage?

- Not readily movable (landscaping, electrical equipment, pipes, trailers on blocks, etc.)

Type	Current Value ($)	Height of water at which damage would occur

- Movable (cars, trucks, trailers, etc.)

Type	Current Value ($)

18. Emergency Measures/Plans:

a. What emergency measures/plans, if any, would you take to reduce damage if eminent flooding was forewarned? ______

___
___
___

b. What is the estimated cost to implement these emergency measures? $________________

c. How much time is required to implement these emergency measures? ________ Hours

Attachment B - Non-Structural Algorithm Flow Chart

Flow chart illustrating the algorithm used to assign nonstructural retrofit treatments to structures in Findlay.

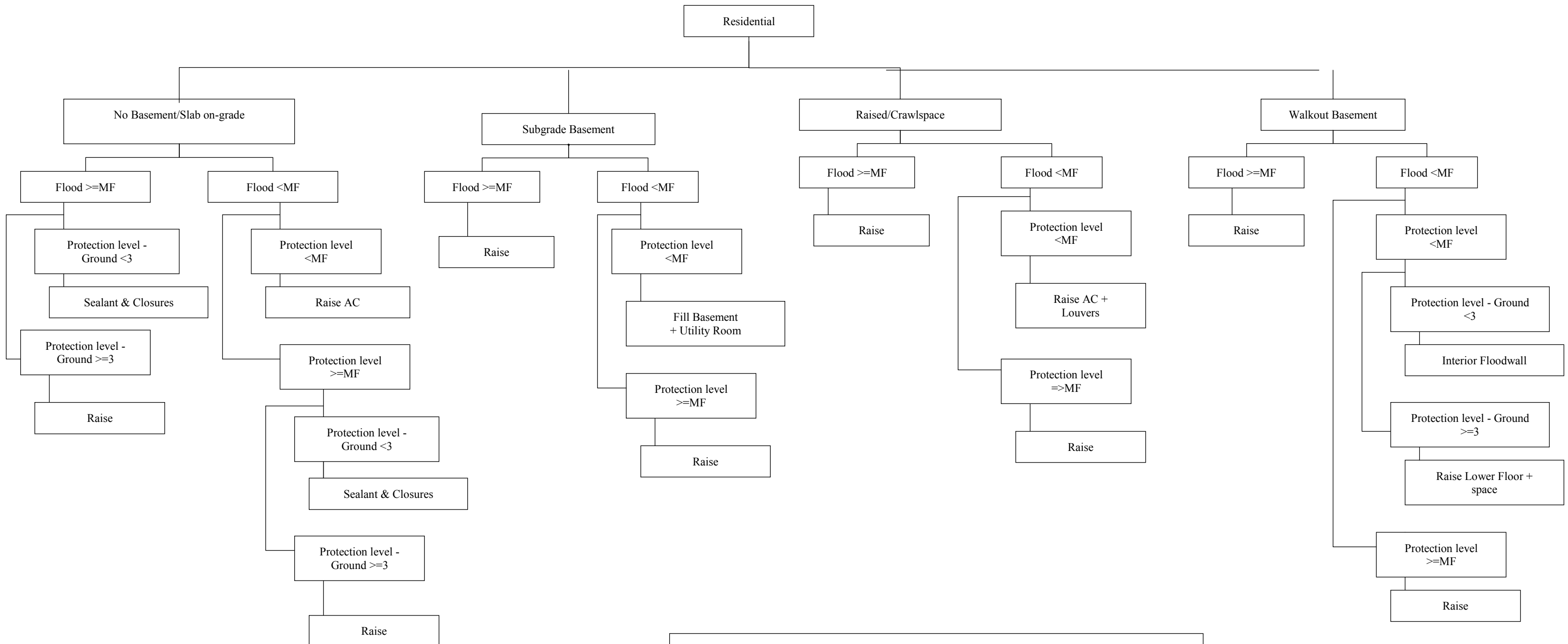
While the algorithm below (and the associated SAS computer program) was originally developed for the Fire Island to Montauk Point (NY) Reformulation Study for USACE-NYD, it has also been applied to numerous other flood risk reduction studies, including the Blanchard Study.

RESIDENTIAL

B.1 FIMP Back Bay Flood Proofing

B.2 Algorithm For Non-structural Flood Protection Treatments

B.3 Residential Structures



Typical Structures
(Structures are defined by foundation type)

1. RAISED (crawl space)
2. SLAB-ON-GRADE
3. BASEMENT (Subgrade (Traditional) and Walkout)
4. BI-LEVEL/RAISED Ranch
5. SPLIT-LEVEL

Assumptions for TYPICAL STRUCTURES

1. (a) Raised(Crawl Space): No utilities are located in the crawl space.
1. (b) Raised(Crawl Space): Wet Flood Proofing includes exterior utilities only.
2. (a) Slab: Wet Flood Proofing is possible when flood depth is below the MF (shallow flooding). Typically exterior utilities only (e.g. AC).
3. Basement: All basements are unfinished.
4. (a) Bi-level/Raised Ranch: The lower floor is a minimum of 4-ft of masonry wall
4. (b) Bi-level/Raised Ranch The lower level is slab on grade; walkout
5. (a) Split-Level: The lower level (LL) is slab on grade; the main floor is raised over a crawl space
5. (b) The Main Floor and the upper level can be separated from the lower level in order to raise the structure.

Criteria for flood proofing TYPICAL STRUCTURES

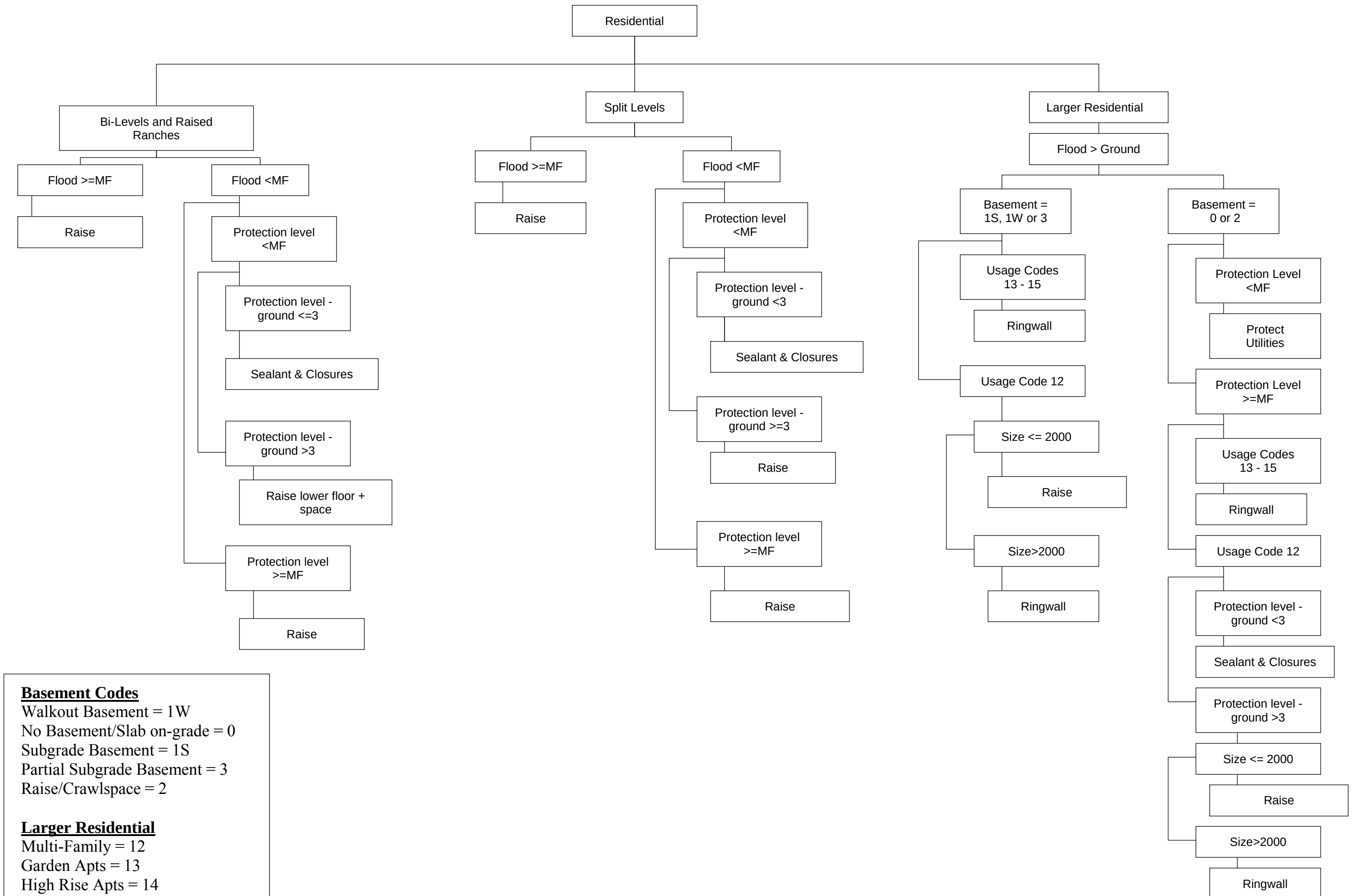
1. Loss of living space due to flood proofing measures will be minimized or replaced.
2. No dry flood proofing for depths>2 feet

FIRE ISLAND TO MONTAUK POINT REFORMULATION STUDY

Non-structural Storm Damage Reduction Alternatives

RESIDENTIAL

FIMP Back Bay Flood Proofing
Algorithm For Non-structural Flood Protection Treatments
esidential Structures



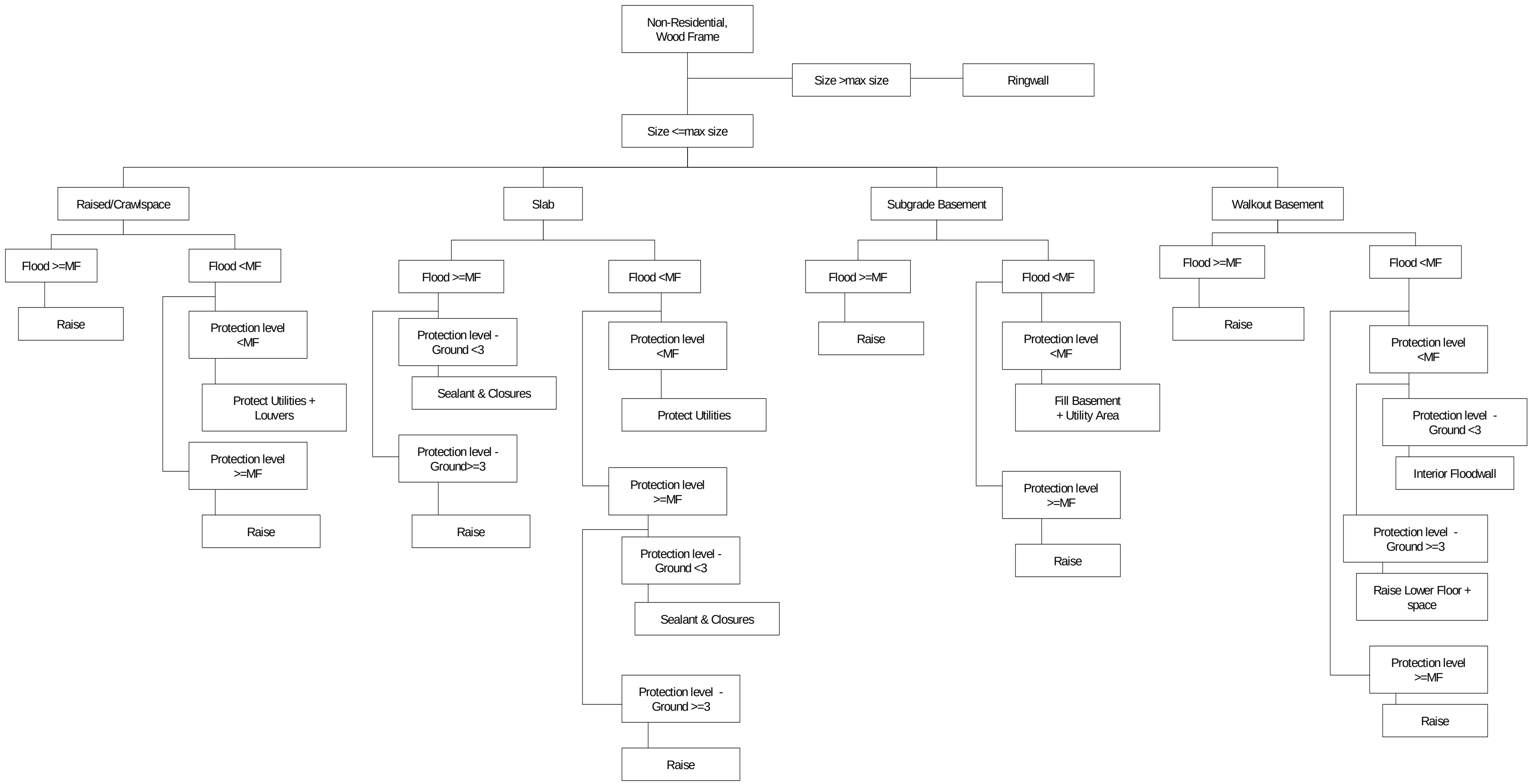
Basement Codes
Walkout Basement = 1W
No Basement/Slab on-grade = 0
Subgrade Basement = 1S
Partial Subgrade Basement = 3
Raise/Crawlspace = 2

Larger Residential
Multi-Family = 12
Garden Apts = 13
High Rise Apts = 14
Townhouses = 15

NON-RESIDENTIAL

WOOD FRAME

Figure 12
FIMP Back Bay Flood Proofing
Algorithm For Non-structural Flood Protection Treatments
Nonresidential Structures (Wood Frame)



Basement Codes
Walkout Basement = 1W
No Basement/Slab on-grade = 0
Subgrade Basement = 1S
Partial Subgrade Basement = 3
Raise/Crawlspace = 2

NON-RESIDENTIAL

MASONRY

Figure 12, continued
FIMP Back Bay Flood Proofing
Algorithm For Non-structural Flood Protection Treatments
Nonresidential Structures (Masonry)